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DEFENSE SYSTEMS DIVISION

LEVEL II

DEVELOPMENT OF A PROTOTYPE AUTOMATED ASSEMBLY MACHINE PRODUCTION LINE FOR THE AREA DENIAL ARTILLERY MUNITION (ADAM)

Final Technical Report

November 1977

Prepared by

Honeywell Inc.
Defense Systems Division
600 Second Street NE
Hopkins, Minnesota 55343

Under Contract
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For

The US Army Armament Research and Development Command
Dover, New Jersey 07801

Honeywell

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Contract DAAA21-73-C-0770 was awarded to the Honeywell Defense Systems Division on 5 July 1973. It called for a two-phase program to develop a prototype line of automated assembly machines for production of ADAM. An engineering study was conducted to review all the assembly operations and to ensure that the list of machines was feasible. With the completion of the study and the establishment of a line of prototype machines, complete sets of general and detailed machine specifications were written. Machine manu-

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facturers were then solicited, and the bid presented by the Honeywell Machine Development Laboratory was ultimately accepted. The machine design, development, and build efforts then started. During the check test build (Contract DAAA21-75-C-0168), it was recognized that improvements and new concepts were required to have the automated assembly machines perform efficiently. Contract modification P00007 called for station-by-station and function reviews of each machine. Contract modification P00009 authorized the retooling of the machines to reflect the latest concepts and design changes. The Honeywell Machine Development Laboratory proceeded with making the changes and delivered the completed machines to the manufacturing facility for use in the production of ADAM. A second machine concept study was initiated under contract modification P00011 to establish the number and types of machines required to balance the line and support a production rate of 140,000 units per month. The manufacture of machines proposed in this concept study was ultimately funded under Contract DAAK10-77-C-0018.

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INTRODUCTION

Contract DAAA21-73-C-0770 was awarded to the Honeywell Defense Systems Division on 5 July 1973. It called for a two-phase program to develop a prototype line of automated assembly machines for production of the Area Denial Artillery Munition (ADAM).

ADAM is a wedge-shaped munition packaged in the XM483 shell and delivered as the XM692 155mm projectile. The feasibility of ADAM was demonstrated by Honeywell under Contract DAAA21-67-C-0533 (1967-1969). ADAM components were designed and integrated under Contract DAAA21-70-C-0096 (1969-1971). The system development of ADAM was completed under Contract DAAA21-71-C-0599 (1971-1973).

In January 1973, Honeywell received Contract DAAA21-73-C-0286 for Development Testing/Operational Testing (DT/OT-II) of ADAM. This program, which ran concurrently with the program reported herein, furnished some input in the form of findings from a series of product improvement studies.

Development of the prototype line of automated assembly machines for ADAM required preliminary study and preparation prior to the purchase or fabrication of the machines.

An engineering study was conducted to review all the assembly operations and to ensure that the list of machines, as proposed, was feasible.

With the completion of the engineering study and the establishment of a line of prototype machines, complete sets of general and detailed machine specifications were written to establish the requirements for each of the machines on the proposed line. The specifications were reviewed with Honeywell management and received approval by ARRADCOM.

A list of machine manufacturers was compiled and approved by ARRADCOM, and each machine manufacturer, in turn, was requested to attend a bidders conference held at Honeywell. The bidders conference was attended by personnel from Honeywell and ARRADCOM, and each of the machines and their requirements were reviewed with the potential vendors. Bids were submitted by the interested vendors and also by the Honeywell Machine Development Laboratory. These bids were reviewed by Honeywell personnel and approved by ARRADCOM. The bid presented by the Honeywell Machine Development Laboratory was ultimately accepted.

The machine design, development, and build efforts started, and it was planned to use the prototype line of machines in the build of the check test units (Contract DAAA21-75-C-0168). During the check test build, it was recognized that improvements and new concepts were required to have the automated assembly machines perform efficiently. Contract modification P00007 was initiated to cover station-by-station concept and function reviews of each machine. Recommendations for redesign and rework were documented and submitted to the Contract Project Officer for approval.

The release of the contract modification P00009 authorized the retooling of the machines to reflect the latest concepts and design changes. The Honeywell Machine Development Laboratory proceeded with making the changes and delivered the completed machines to the manufacturing facility for use in the production of ADAM. The manufacturing facility is a Honeywell facility in the Twin City Army Ammunition Plant (TCAAP Building 103), New Brighton, Minnesota.

A second machine concept study was initiated under contract modification P000011 to establish the number and types of machines required to balance the line and support a production rate of 140,000 units per month on a 500-hour-month basis. The balanced line concept study describing the quantity and types of additional machines and introducing the latest concepts to the

machine line was completed and ultimately approved by ARRADCOM. The manufacture of machines proposed in this concept study was ultimately funded under Contract DAAK10-77-C-0018.

Figure 1 shows a flow chart of the ADAM automated assembly machine line and Table 1 defines the line.

Machines that stop only when necessary have an optimum net output per hour that approaches the base cycle rate. These COMSTAR 4 microprocessor controlled machines have memory capability so the status of the assemblies in each nest is known to the controller at all times. At those probe stations where an assembly is labeled bad or incomplete, and it has been predetermined that this defective assembly presents no hazard to the machine or operator, the machine will not perform additional operations at subsequent work stations and continue to cycle rather than stop. Furthermore, it will ignore further inspection probe results and the defective or incomplete assembly will be removed at a reject station for sort and salvage operations.

If an inspection probe detects defective assemblies in a predetermined number (usually three) of consecutive nests, thus indicating a parts feeding jam or machine problems at a preceding work station, the controller will stop the machine at a cycle angle with display numbers to allow the operator to safely make the appropriate corrections.

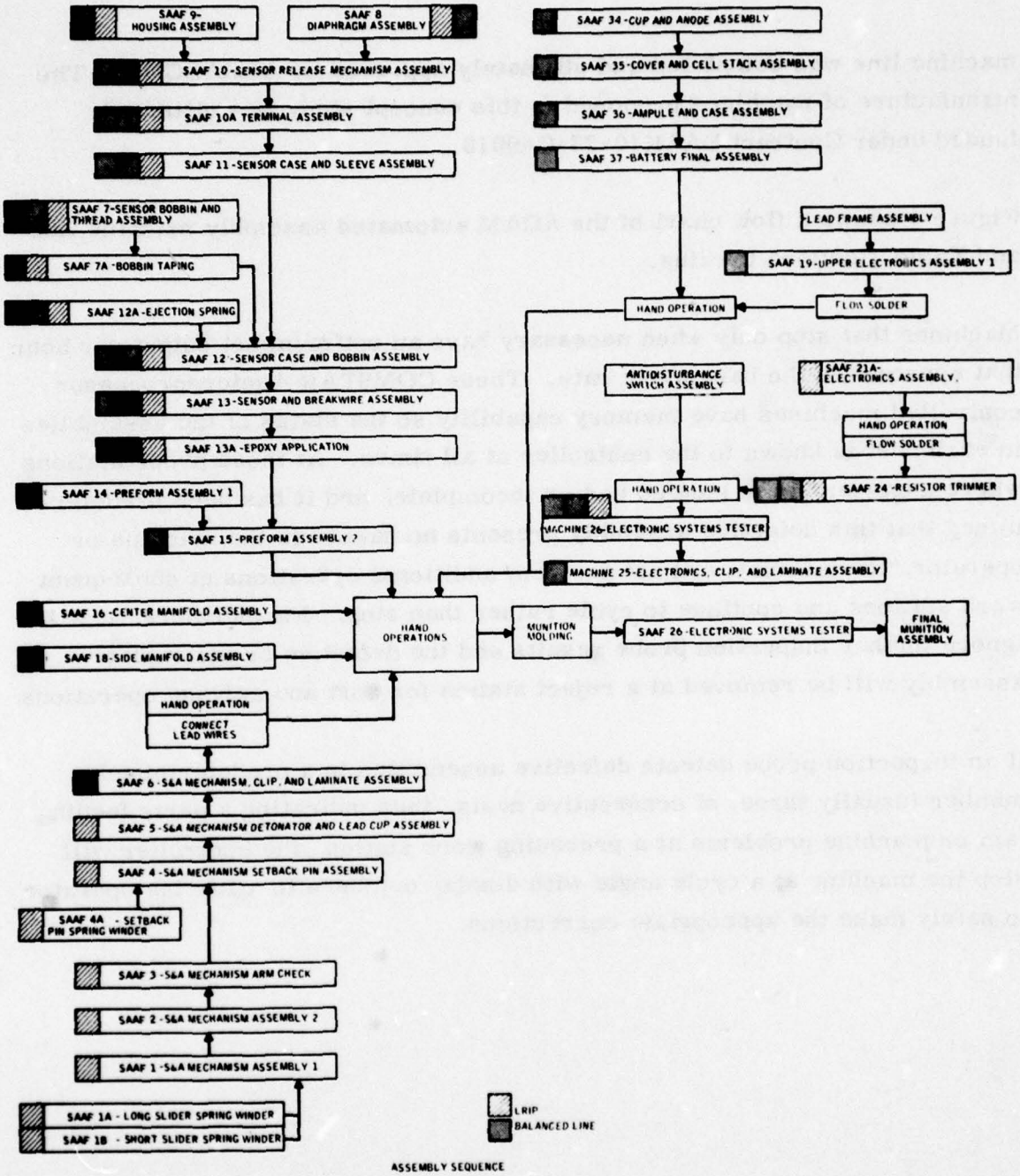

Figure 1. ADAM Automated Assembly Machine Production Line

Table 1. ADAM Automated Assembly Machine Production Line Definition

	Required for Program		Number for Line	
	Machine Number	Description	Prototype	Balanced
S&A Mechanism	1	S&A Mechanism Subassembly 1	1	1
	1A	Short Slider Spring Winder	1	1
	1B	Long Slider Spring Winder	1	1
	2	S&A Mechanism Subassembly 2	1	1
	3	S&A Mechanism Arm Check	1	1
	4	S&A Mechanism Setback Pin Assembly	1	1
	4A	Setback Pin Spring Winder	1	1
	5	S&A Mechanism Detonator and Lead Cup Assembly	1	1
	6	S&A Mechanism Clip and Laminate Assembly	0	1
Sensor	7	Sensor Bobbin Assembly	1	4
	8	Diaphragm Assembly	1	1
	9	Tube/Housing Assembly	1	1
	10	Sensor Release Mechanism Assembly	1	2
	11	Sensor Release Mechanism and Case Assembly	1	2
	12	Sensor Case and Bobbin Assembly	1	2
	12A	Ejection Spring Winder	1	1
	13	Sensor Assembly	1	2
Preform	14	Preform and Clip Assembly	0	1
	15	Preform and Sensor Assembly	0	1
	16	Center Manifold Assembly	0	1
	18	Side Manifold Assembly	0	1
Upper Electronics	19	Upper Electronics Assembly	0	1
Lower Electronics	21A	Lower Electronics Assembly	1	1
	24	Resistor Trimmer	1	2
	25	Electronics Clip and Laminate Assembly	0	1
	26	Electronic Systems Tester	1	2
Battery Assembly	34	Cover and Collar Assembly	0	1
	35	Cup, Cathode, and Cover Assembly	0	1
	36	Ampule and Case Assembly	0	1
	37	Battery Final Assembly	0	1

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MACHINE AND STATION DESCRIPTIONS

MACHINE 1 – S&A MECHANISM SUBASSEMBLY 1

Machine Description

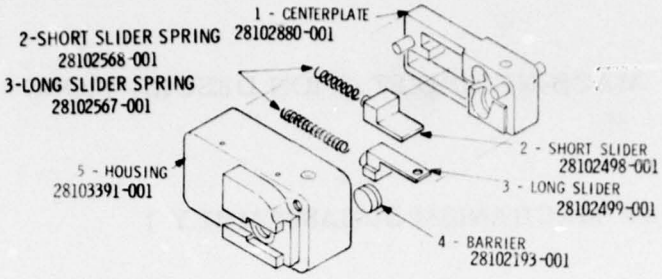
This automated assembly machine is a 20-station, single-nested, dial-index type machine (see Figure 2). It assembles S&A mechanism subassembly 1 (28109292-001), consisting of the centerplate into which is assembled the long slider, long slider spring, short slider, short slider spring, and one barrier. The housing is assembled over the subassembly to capture the above listed parts, and two dowels, protruding from the centerplate, are staked to hold the subassembly together. One subassembly is produced with each cycle of the machine.

All parts are vibratory bowl fed except for the two springs. The springs are presented to the machine in stick magazines previously filled at the spring winders. Completed subassemblies are ejected into magazines and defective subassemblies are rejected to a container. See Table 2 for Machine No. 1 Rates.

Station Descriptions (See Figure 3)

Station 1 – Vibratory Bowl Feed Centerplate -- Centerplates are loaded into the vibratory feed bowl which orients and discharges them into a feed track. A mechanical pickup head lifts a part from the track and deposits it into the nest.

Station 2 – Probe Presence and Position of Centerplate -- The probe comes down with the tooling plate and rests on the part: Two microswitches either make or break a circuit to show if the part is in proper position or missing.



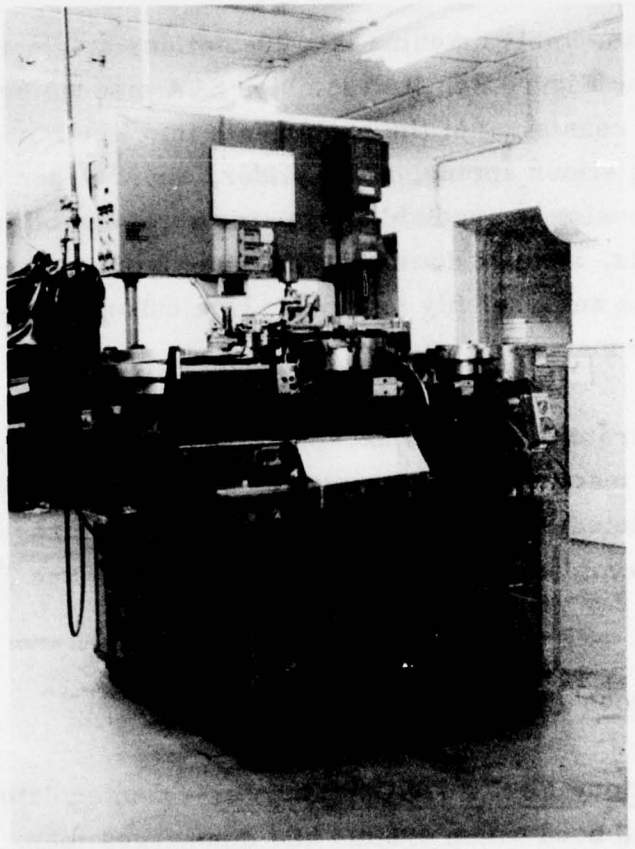


Figure 2. Machine 1 - S&A Mechanism Subassembly 1

Table 2. Machine No. 1 Rates (Base OML 315)

	Design	Actual (11/77)
Cycles/Minute	50	30
No. of Tools	1	1
Average Machine Acceptance Rate per 60-Minute Hour	1500	346
Machine Accepted Assembly Rate	69.4%	75.9%
Current Reject Rate		26.3%
Current Scrap Rate		1.2%

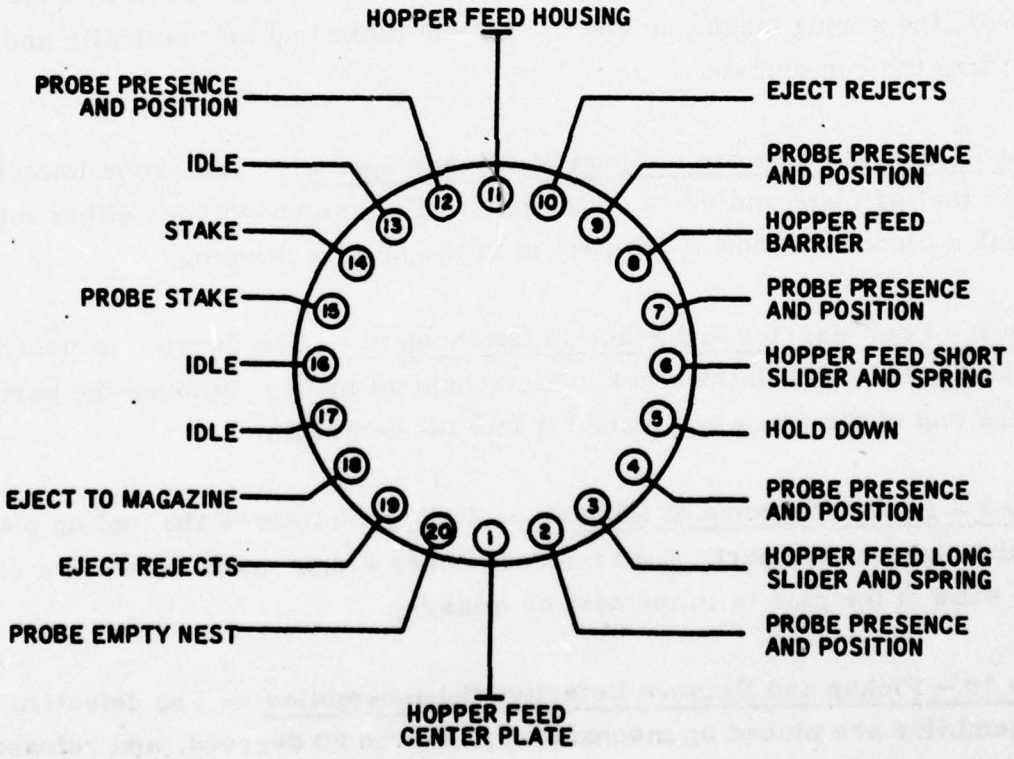


Figure 3 - Machine No. 1 - Station Layout

Station 3 – Feed and Place Long Slider and Spring -- Long sliders are oriented and fed by a vibratory feed bowl and released to the feed track. The springs are air blown into the nest from the spring mechanism.

Station 4 – Probe Presence of Long Slider and Spring -- The probe lowers with the tooling plate and rests on the part. Two microswitches either make or break a circuit to show whether the part is in the nest or missing.

Station 5 – Locate Parts -- Station 5 consists of a spring-loaded hold-down to keep parts properly located in the nest.

Station 6 – Feed and Place Short Slider and Spring -- Short sliders are fed into a track by a vibratory feed bowl. The springs are air blown into the nest from the spring magazine and the part is picked up mechanically and placed into the centerplate.

Station 7 – Probe Presence of Short Slider and Spring -- The probe lowers with the tooling plate and rests on the part. Two microswitches either make or break a circuit to show if the part is in the nest or missing.

Station 8 – Feed Barrier and Place in Centerplate -- The barrier is fed from a vibratory feed bowl to the track. A mechanical pickup removes the part from the end of the track and places it into the centerplate.

Station 9 – Probe Presence of Barrier -- The probe follows the tooling plate down and rests on the part. Two microswitches either make or break a circuit to show if the part is in the nest or missing.

Station 10 – Pickup and Remove Defective Subassemblies -- The defective subassemblies are picked up mechanically, moved 90 degrees, and released into a container.

Station 11 – Pickup and Place Housing on Top of Centerplate -- The housings are loaded into a vibratory feed bowl and fed down the track. A mechanical pickup head picks up the part and deposits it into the nest.

Station 12 – Probe Presence of Housing in Nest -- The probe follows the tooling plate down and rests on the part. Two microswitches actuate to show whether the part is in the nest or missing.

Station 13 -- Idle.

Station 14 – Stake Two Dowels to Rivet Housing to Centerplate -- Staking punches mounted to the tooling plate contact the part and an air cylinder delivers the power to the punches, causing the staking action.

Station 15 – Probe Stake -- An electromechanical probe mounted to the upper tooling plate rests on the part. Two microswitches either make or break a circuit to show whether the dowels are properly staked or missing.

Station 16 -- Idle.

Station 17 -- Idle.

Station 18 – Eject to Magazine -- The finished subassemblies are mechanically removed from the nest to a track and then are pushed from this track into an extruded aluminum magazine. When the magazine is full, it is pushed sideways in the magazine rack and a new magazine falls into place.

Station 19 – Reject to Container -- The subassemblies that have been rejected by the probes are mechanically picked up and dropped into a reject container.

Station 20 – Probe Empty Nest -- The probe is lowered by the tooling plate and microswitches open or close a circuit to show that the nest is empty or that a part is still in the nest. If a part remains in the nest, the machine will stop before it reaches Station 1.

MACHINE 1A – SHORT SLIDER SPRING WINDER

Machine Description

The ADAM short slider spring winder (see Figure 4) is a Sleeper and Hartley Universal spring coiler. This machine winds the short slider spring (28102568-001) that goes into S&A mechanism subassembly 1 at Machine 1. One spring is wound with each cycle of the winder. The 0.009-inch-diameter music wire is dereeled from a coil and threaded through the tensioning device rollers to the feed rolls of the winder. The wire is coiled, cut to length, and air ejected to magazines. (See Table 3 for Machine No. 1A Rates.)

Station Descriptions

Station 1 – Dereel -- The reel of wire is loaded onto a motor-driven shaft. The wire is threaded around 3-inch-diameter wheels attached to a slack arm. This slack arm maintains light wire tension and operates switches that turn the reel motor on and off as required to provide wire for the winder.

Station 2 – Wind Spring -- Wire is pulled into the machine through wire guides by power-driven feed rolls. It is pushed around an arbor and controlled by the coiling point and pitch tool. The resulting spring is cut off and picked up in a receiver tube and blown clear of the machine by a venturii feed air blast into a plastic transfer tube.

Station 3 – Load Springs into Magazines -- The spring magazines are loaded into a vertical stacker and indexed horizontally with a square motion drive. This motion is timed to receive a spring from the transfer tube into each magazine cavity at the time the winder blows it clear. When the magazine is filled, a photocell senses its condition and operates a cross-feed to push the magazine clear for hand loading into trays for subsequent oven stress relief.

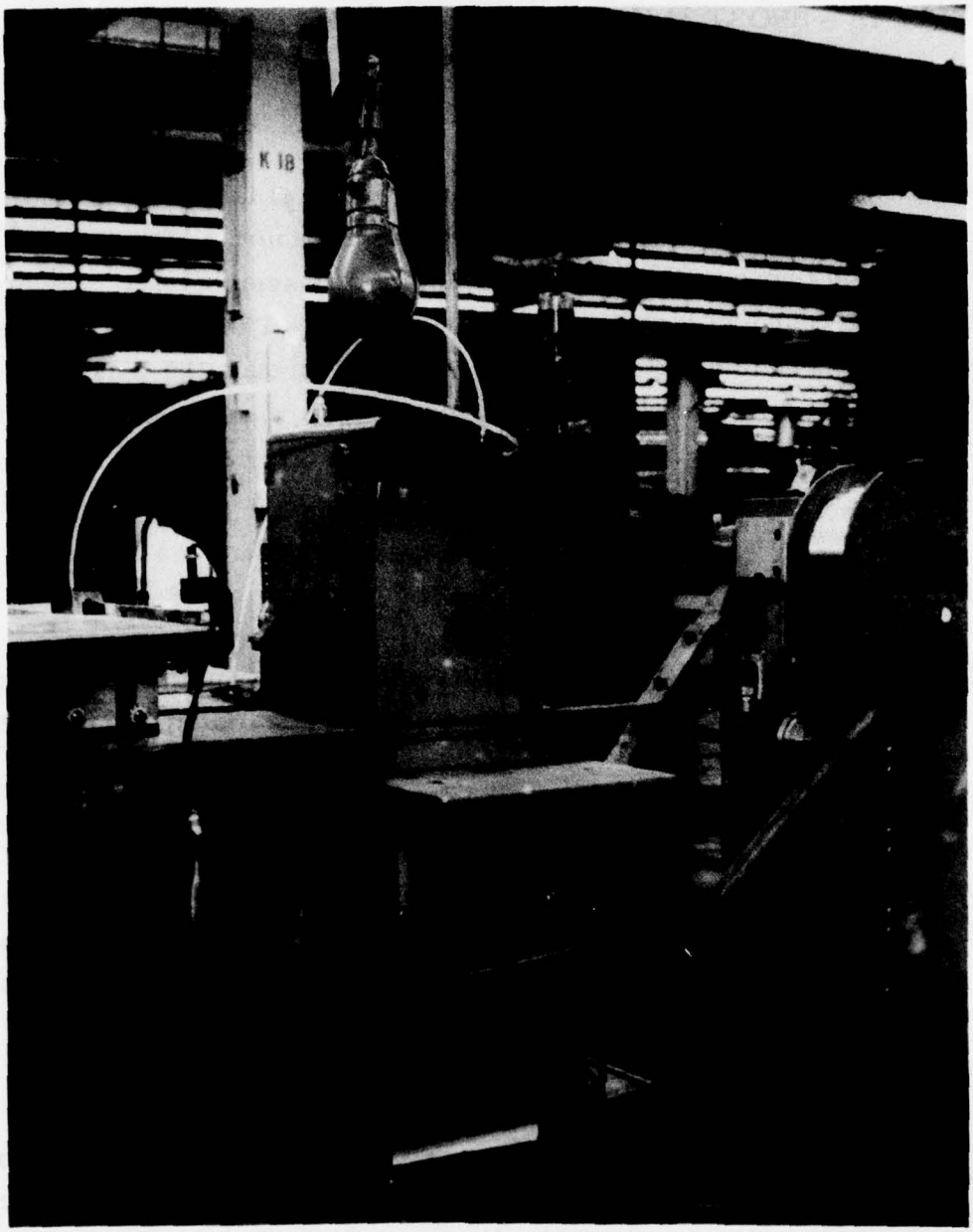


Figure 4. Machine No. 1A - Short Slider Spring Winder

Table 3. Machine No. 1A Rates (Base Sleeper Hartley)

	Design	Actual (11/77)	
Cycles/Minute	---	---	Not Available
No. of Tools	---	---	
Average Machine Acceptance Rate per 60-Minute Hour	---	---	
Machine Accepted Assembly Rate	---%	---%	
Current Reject Rate		(1)%	
Current Scrap Rate		1.7%	
(1) No machine rejection			

MACHINE 1B – LONG SLIDER SPRING WINDER

Machine Description

The ADAM long slider spring winder (see Figure 5) is a Sleeper and Hartley Universal spring coiler. This machine winds the long slider spring (28102561-001) that goes into S&A mechanism subassembly 1 at Machine 1. One spring is wound with each cycle of the winder. The 0.009-inch-diameter music wire is dereeled from a coil and threaded through the tensioning device rollers to the feed rolls of the winder. The wire is coiled, cut to length and air ejected to magazines. See Table 4 for Machine No. 1B Rates.

Station Descriptions

Station 1 – Dereel -- The reel of wire is loaded onto a motor-driven shaft. The wire is threaded around 3-inch-diameter wheels attached to a slack arm. This slack arm maintains light wire tension and operates switches that turn the reel motor on and off as required to provide wire for the winder.

Station 2 – Wing Spring -- Wire is pulled into the machine through wire guides by power-driven feed rolls. It is pushed around an arbor and controlled by the coiling point and pitch tool. The resulting spring is cut off and picked up in a receiver tube and blown clear of the machine by a venturii feed air blast into a plastic transfer tube.

Station 3 – Load Springs into Magazines -- The spring magazines are loaded into a vertical stacker and indexed horizontally with a square motion drive. This motion is timed to receive a spring from the transfer tube into each magazine cavity at the time the winder blows it clear. When the magazine is filled, a photocell senses its condition and operates a cross-feed to push the magazine clear for hand loading into trays for subsequent oven stress relief.

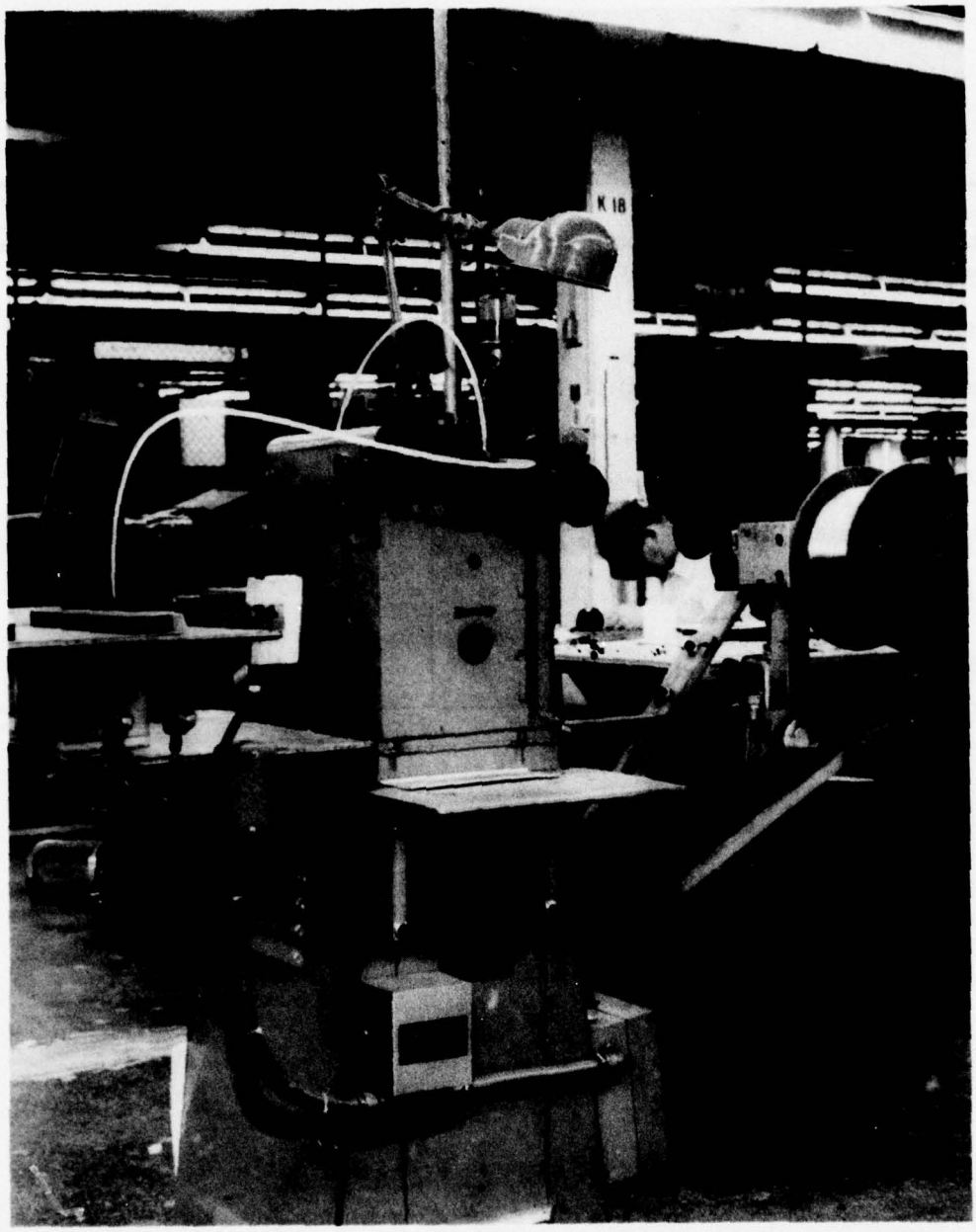


Figure 5. Machine No. 1B - Long Slider Spring Winder

Table 4. Machine No. 1B Rates (Base Sleeper Hartley)

	Design	Actual (11/77)	
Cycles/Minute	---	---	Not Available
No. of Tools	---	---	
Average Machine Acceptance Rate per 60-Minute Hour	---	---	
Machine Accepted Assembly Rate	---%	---%	
Current Reject Rate		(1)%	
Current Scrap Rate		1.7%	
(1) No machine rejection			

MACHINE 2 – S&A MECHANISM SUBASSEMBLY 2

Machine Description

Machine 2 is a 20-station, single-nested, dial-index machine (see Figure 6). This machine assembles S&A mechanism 2 (28109293-001), consisting of S&A mechanism subassembly 1 (from Machine 1) into which is assembled the barrier, cork rubber gasket, and detonator sideplate. Two dowels protruding from the centerplate go through the detonator sideplate and are staked to hold the subassemblies together. One subassembly is produced with each cycle of the machine.

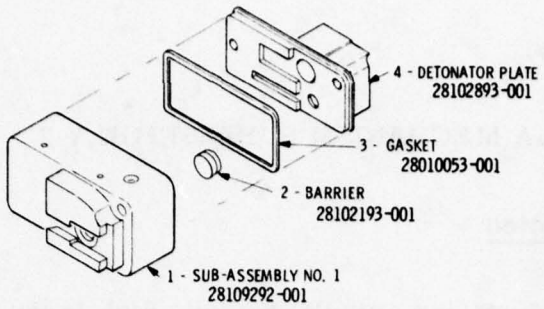
S&A mechanism subassembly 1 is magazine fed and all other parts are vibratory bowl fed. Completed subassemblies are ejected into magazines and defective subassemblies are rejected to a container. See Table 5 for Machine No. 2 Rates.

Station Descriptions (See Figure 7)

Station 1 – Magazine Feed S&A Mechanism Subassembly 1 -- S&A mechanism subassembly 1 from Machine 1 is magazine fed by gravity to a mechanical pickup which places the subassembly into the nest.

Station 2 -- Idle.

Station 3 – Probe Presence of Long Slider -- An electromechanical probe mounted on the upper tooling plate checks the presence of the long slider in the subassembly. If the long slider is missing or misaligned due to missing spring, the tooling plate will elevate to the up position and stop. This condition must be corrected before the machine will continue to cycle.



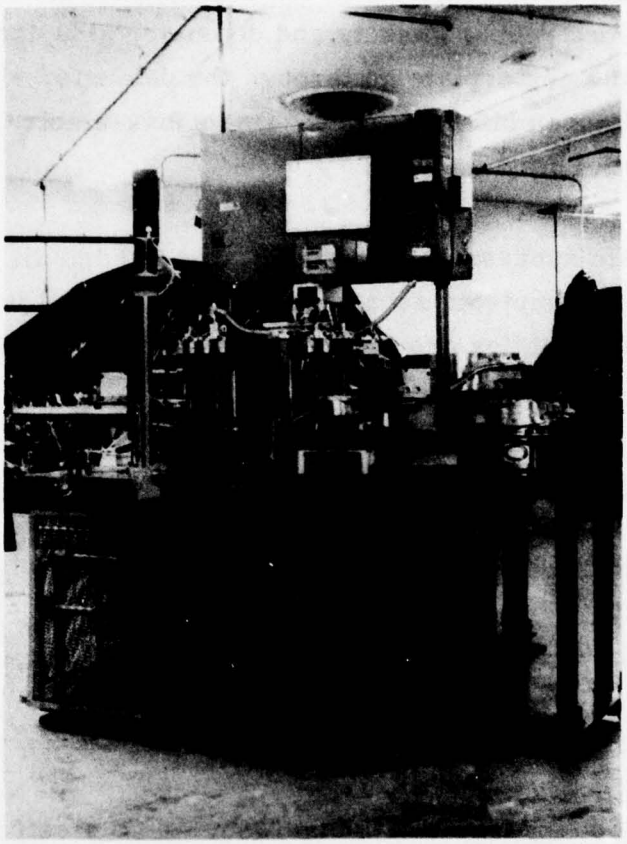


Figure 6. Machine No. 2 - S&A Mechanism Subassembly 2

Table 5. Machine No. 2 Rates (Base OML 315)

	Design	Actual (11/77)
Cycles/Minute	50	36
No. of Tools	1	1
Average Machine Acceptance Rate per 60-Minute Hour	1500	370
Machine Accepted Assembly Rate	69.4%	95.8%
Current Reject Rate		3.4%
Current Scrap Rate		2.5%

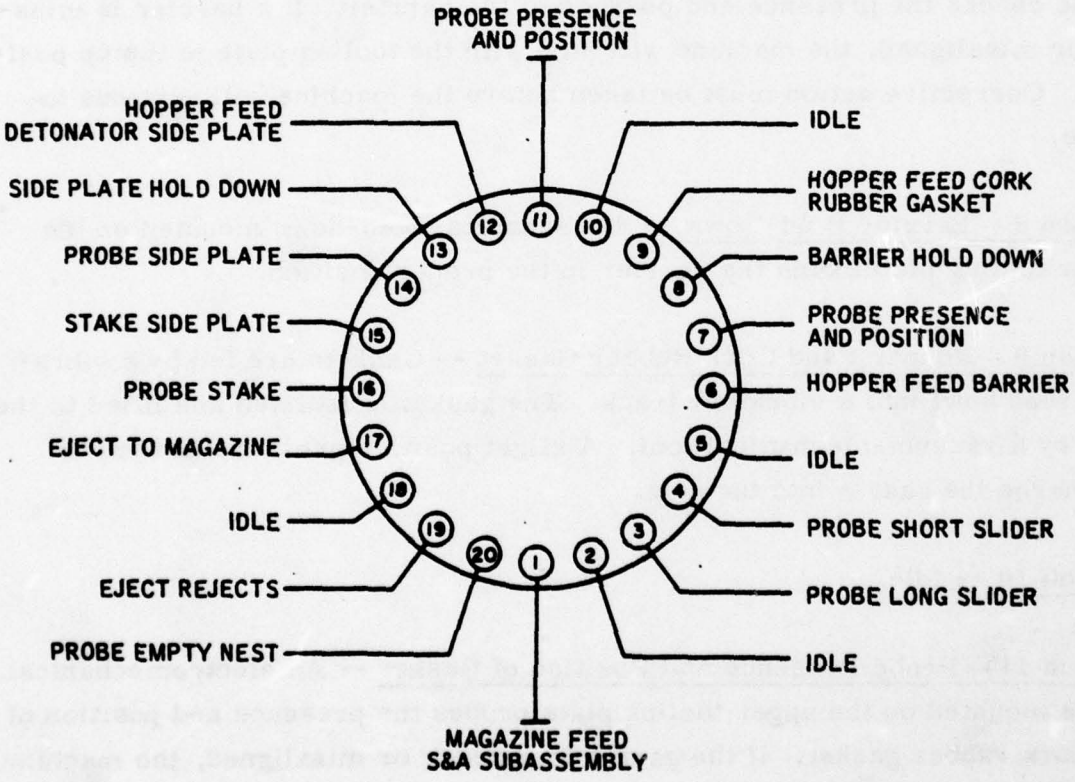


Figure 7. Machine No. 2 - Station Layout

Station 4 – Probe Presence of Short Slider -- An electromechanical probe mounted on the upper tooling plate probes the presence of the short slider in the subassembly. A missing or misaligned (due to missing spring) short slider will cause the machine to stop with the tooling plate in the up position. Corrective action must be taken before the machine will continue to cycle.

Station 5 -- Idle.

Station 6 – Hopper Feed Barrier -- Barriers are vibratory bowl fed into a vibratory track. At the end of the track is a parts separator which locates the barrier for mechanical pickup and transfer into the subassembly.

Station 7 – Probe Presence and Position of Barrier -- An electromechanical probe checks the presence and position of the barrier. If a barrier is missing or misaligned, the machine will stop with the tooling plate in the up position. Corrective action must be taken before the machine will continue to cycle.

Station 8 – Barrier Hold-Down -- A mechanical hold-down mounted on the upper tooling plate holds the barrier in the proper position.

Station 9 – Hopper Feed Cork Rubber Gasket -- Gaskets are fed by a vibratory feed bowl into a vibratory track. The gasket is isolated and lifted to the nest by a vacuum-mechanical tool. A slight positive pressure is used to discharge the gasket into the nest.

Station 10 -- Idle.

Station 11 – Probe Presence and Position of Gasket -- An electromechanical probe mounted on the upper tooling plate probes the presence and position of the cork rubber gasket. If the gasket is missing or misaligned, the machine will stop with the tooling plate in the up position. The condition must be corrected before the machine will continue to cycle.

Station 12 – Hopper Feed Detonator Sideplate -- The detonator sideplate is fed by a vibratory feed bowl to a vibratory feed track. The end of the track has an isolator which permits a pneumatic-mechanical pickup to place the sideplate into the subassembly.

Station 13 – Detonator Sideplate Hold-Down -- A mechanical hold-down mounted on the upper tooling plate presses the detonator sideplate into position.

Station 14 – Probe Presence and Position of Detonator Sideplate -- An electromechanical probe checks the presence and position of the detonator sideplate in the subassembly. If the sideplate is missing or misaligned, the machine will stop with the tooling plate in the up position. Corrective action must be taken before the machine will continue to cycle.

Station 15 – Stake Detonator Sideplate -- A pneumatic compression riveter is used to stake the two dowels through the detonator sideplate, thus sealing the sideplate to the housing.

Station 16 – Probe Stake -- An electromechanical probe mounted to the upper tooling plate checks the presence and dimension of the stake.

Station 17 – Eject to Magazine -- A mechanical pickup tool takes the completed, accepted subassemblies and places them on a slider which inserts them into the magazine.

Station 18 -- Idle.

Station 19 – Reject to Container -- Rejected subassemblies are deposited into a container.

Station 20 – Probe Empty Nest -- An electromechanical probe checks the empty nest to ensure that parts do not remain in the nest before advancing to station 1.

MACHINE 3 – S&A MECHANISM ARM CHECK

Machine Description

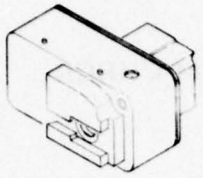
Machine 3 is a 30-station, double-nested, dial-index machine which checks the S&A mechanism subassembly from machines 1 and 2 for the high-arm and low-arm requirements. See Figure 8.

The machine has four double-spin stations. The first spin station performs the high-arm check. A barrier support pin is inserted into the subassembly before the high-arm check to retain the two barriers and prevent them from sliding into the locked-out position in the barrier well.

At the high-arm spin station, two subassemblies are transferred from the nest directly into the spin head. After the spin cycle, the two subassemblies are returned to the nest. At the next station, the barriers are probed to determine whether or not they are in the proper position.

The second spin station recocks the subassemblies before removal of the barrier support pin. The third and fourth redundant spin stations are both low-arm spin stations. All subassemblies are subjected to two arm checks. All acceptable subassemblies are marked and checked for the presence of the mark. The mark provides identification throughout the remaining operations.

Each spin station is driven by a motor tachometer. A control box containing the driving and monitoring electronics for these stations is separate from the main machine controller. The spin stations are recalibrated once per month by the Instrument Lab. Dated seals are placed on the motor tachometer and over the access to the control box.



SPIN TO ARM

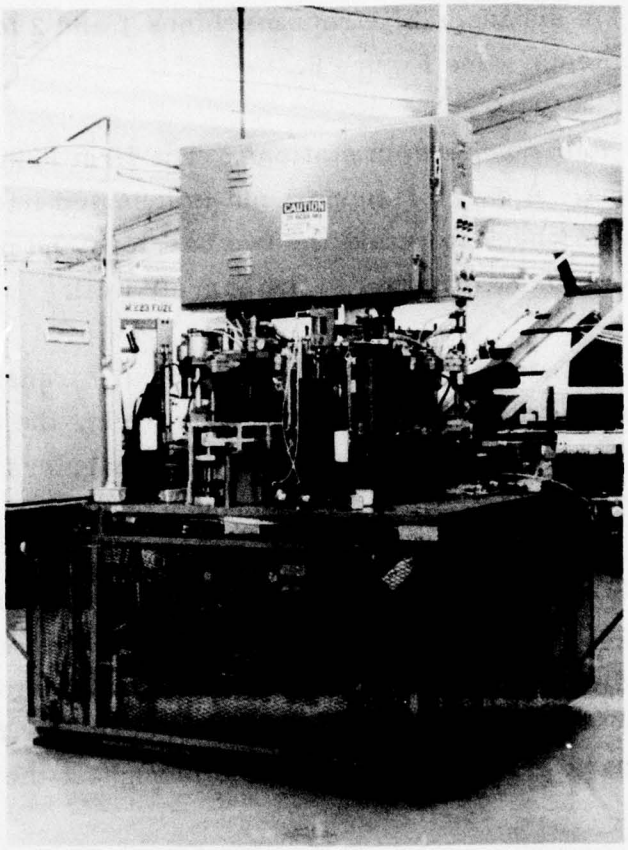


Figure 8. Machine No. 3 - S&A Mechanism Arm Check

If the machine stops during production with a display number corresponding to one of the spin stations, a light on the control box will indicate which fault of the spin station caused the stoppage. The Instrument Lab must repair the spin station's fault before the operator can restart the machine.

Acceptable subassemblies are placed into magazines and defective high-arm subassemblies are rejected to a container. The first low-arm probe ejects defective low-arm subassemblies into a locked container, and defective low-arm subassemblies detected by the second low-arm probe cause the machine to stop with the tooling plate in the down position, which requires a key to restart the machine. See Table 6 for Machine No. 3 Rates.

Station Descriptions (See Figure 9)

Station 1 – Magazine Feed Two S&A Mechanism Subassemblies from Machine 2 -- S&A mechanism subassemblies from Machine 2 are magazine fed to a mechanical pickup which places the two subassemblies into the dual nests.

Station 2 – Probe Presence of Two S&A MechanismSubassemblies -- An electromechanical probe mounted on the upper tooling plate checks the presence of the S&A mechanism subassembly in each nest. If either one or both of the subassemblies is missing, the tooling plate will elevate to the up position and stop. This condition must be corrected before the machine will continue to cycle.

Station 3 -- Idle.

Station 4 – Hopper Feed Two Barrier Support Pins -- The barrier support pins are bulk loaded into a vibratory feed bowl. The bowl properly orients the pins and discharges them to a vibratory track where a pneumatic mechanical pickup transfers the pins into the subassembly.

Station 5 -- Idle.

Station 6 – Probe Presence and Position Barrier Support Pins -- An electromechanical probe checks both nests for presence and position of the barrier support pins. If either or both of the support pins is missing, the machine will stop with the tooling plate in the up position. Corrective action must be taken before the machine will continue to cycle.

Station 7 – Spin for High Arm -- The subassemblies are lifted from the dual nests and placed in the high-arm spin head. This station spins the subassemblies through the high-arm sequence. After high-speed spinning, the subassemblies are lowered back into the nest.

Table 6. Machine No. 3 Rates (Base OML 189)

	Design	Actual (11/77)
Cycles/Minute	40	16
No. of Tools	2	2
Average Machine Acceptance Rate per 60-Minute Hour	1350	327
Machine Accepted Assembly Rate	70.3%	72.4%
Current Reject Rate		16.6%
Current Scrap Rate		12.2%

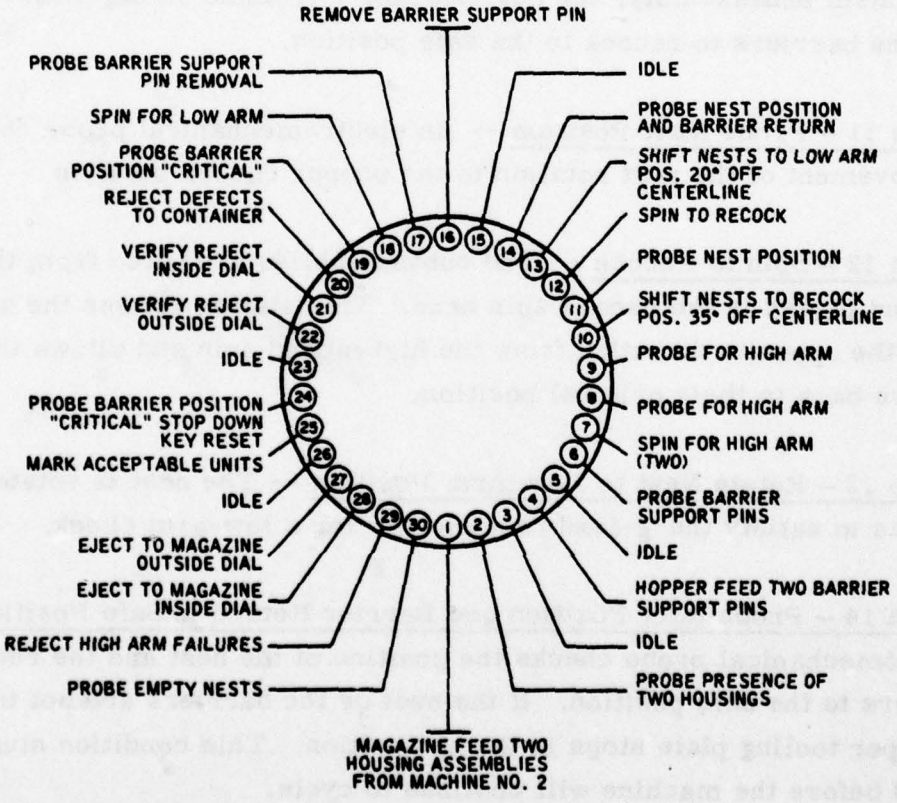


Figure 9. Machine No. 3 - Station Layout

Station 8 – Probe Presence of Armed Barriers -- An electromechanical probe checks the presence of the barriers in the armed condition. If the barrier has not moved to the armed position, the identity of the given subassembly is stored in the machine's memory and the subassembly will be ejected at a later time. If the barrier is in the proper position, the subassembly will continue to the next station.

Station 9 – Probe Presence of Armed Barriers (Redundant) -- This station confirms the findings of Station 8. It uses the same probing technique for rechecking the position of the barriers.

Station 10 – Rotate Nest to Recock Position -- To recock the armed S&A mechanism subassembly, the nest position is rotated 35 degrees. This permits the barriers to recock to the safe position.

Station 11 – Probe Nest Position -- An electromechanical probe checks for the movement of the nest rotation to the proper recock position.

Station 12 – Spin to Recock -- The subassemblies are lifted from the dual nest and placed in the recock spin head. This station rotates the subassembly in the opposite direction from the high-speed spin and allows the barriers to move back to their original position.

Station 13 – Rotate Nest to Low-Arm Position -- The nest is rotated 20 degrees to satisfy the g-load requirement for a low-arm check.

Station 14 – Probe Nest Position and Barrier Return to Safe Position -- An electromechanical probe checks the position of the nest and the return of the barriers to the safe position. If the nest or the barriers are not in position, the upper tooling plate stops in the up position. This condition must be corrected before the machine will continue to cycle.

Station 15 -- Idle.

Station 16 – Remove Barrier Support Pins -- A mechanical arm removes the barrier support pins from each subassembly and drops them into a container.

Station 17 – Probe Barrier Support Pin Removal -- An electromechanical probe checks the removal of the barrier support pins.

Station 18 – Spin for Low Arm -- The subassemblies are lifted from the dual nests into the low-arm spin head. The subassemblies are spun at the proper spin rate to check for low arm. After spinning the subassemblies are loaded into the nest.

Station 19 – Probe Position of Barrier -- An electromechanical probe checks the presence of the barriers after the low-arm spin. If a barrier is found to have moved, the given subassembly classified as a defective unit. The defective subassembly is identified and stored in the machine memory as a reject.

Station 20 – Reject Low-Arm Defective Subassemblies – The low-arm defective subassemblies are lifted from their respective nests and placed into vertical magazines which are locked containers.

Station 21 – Verify Reject of Low-Arm Defective Subassemblies (Inside Dial) -- An electromechanical probe verifies to the machine memory that the low-arm defective subassemblies in the inside dial were rejected.

Station 22 – Verify Reject of Low-Arm Defective Subassemblies (Outside Dial) -- An electromechanical probe verifies to the machine memory that the low-arm defective subassemblies in the outside dial were rejected.

Station 23 -- Idle.

Station 24 – Probe Position of Barriers -- This is a critical stop down - key start station. An electromechanical probe rechecks the position of the barriers in the subassemblies. If this probe finds any subassembly with a barrier out of position, the machine locks in the tooling plate down position and cannot be restarted. The key for reset is retained by the Inspection department.

Station 25 – Mark Acceptable Subassemblies -- The acceptable subassemblies are indexed over a marking fixture and a small stamped number is applied.

Station 26 – Idle.

Station 27 – Eject to Magazine (Outside Dial) -- The subassemblies from the outside dial are lifted from the nest and mechanically moved into aluminum stick magazines.

Station 28 – Eject to Magazine (Inside Dial) -- The subassemblies from the inside dial are lifted from the nest and mechanically moved into aluminum stick magazines.

Station 29 – Reject High-Arm Defective Subassemblies -- The subassemblies that were rejected for failing the high-arm check at stations 8 and 9 are ejected at this station. The machine memory recalls the defective subassemblies and ejects them vertically into magazines.

Station 30 – Probe Empty Nests -- An electromechanical probe checks the two nests to verify that they are empty and ready to start another cycle.

MACHINE 4 – S&A MECHANISM SETBACK PIN ASSEMBLY

Machine Description

Machine 4 is a 24-station, single-nested, dial-index machine (see Figure 10). This machine assembles the setback pin, setback pin spring, and setback pin cap. The setback pin and spring are fed into the S&A mechanism subassembly, and the cap is pressed in position to hold the parts in place. The detonator shield is assembled and staked. The completed subassembly is turned over (180 degrees) in the nest and a series of probes check for the proper spring rate. A sealing ball is inserted into the assembly and pressed in position to seal the unit. One subassembly is produced with each cycle of the machine.

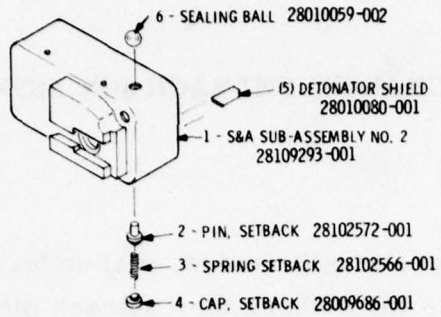
The S&A mechanism and springs are magazine fed and the sealing ball is fed from a plastic container into the subassembly through a tube. All other parts are vibratory bowl fed.

Completed subassemblies are ejected into magazines and defective subassemblies are ejected to a container. See Table 7 for Machine No. 4 Rates.

Station Descriptions (See Figure 11)

Station 1 – Magazine Feed S&A Mechanism Subassembly from Machine 3 -- An S&A mechanism subassembly from Machine 3 is fed in an extruded aluminum magazine to a mechanical pickup which places it into the nest.

Station 2 – Probe Presence of S&A Mechanism Subassembly -- An electromechanical probe mounted on the upper tooling plate checks the presence of the S&A mechanism subassembly. If the subassembly is missing, the tooling plate will elevate to the up position and stop. This condition must be corrected before the machine will continue to cycle.



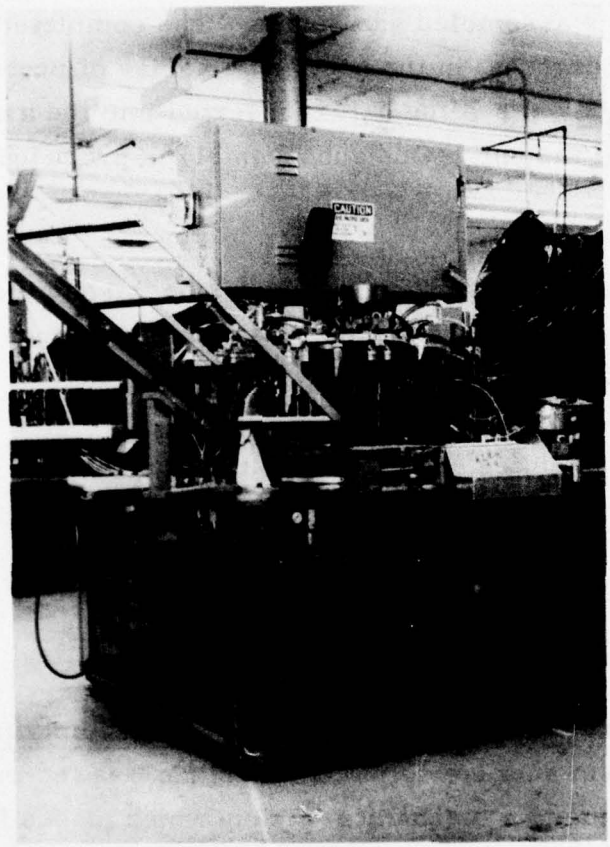


Figure 10. Machine ;No. 4 - S&A Mechanism Setback Pin Assembly

Table 7. Machine No. 4 Rates (Base OML 189)

	Design	Actual (11/77)
Cycles/Minute	40	30
No. of Tools	2	2
Average Machine Acceptance Rate per 60-Minute Hour	1500	157
Machine Accepted Assembly Rate	34.7%	83.8%
Current Reject Rate		14.6%
Current Scrap Rate		6.3%

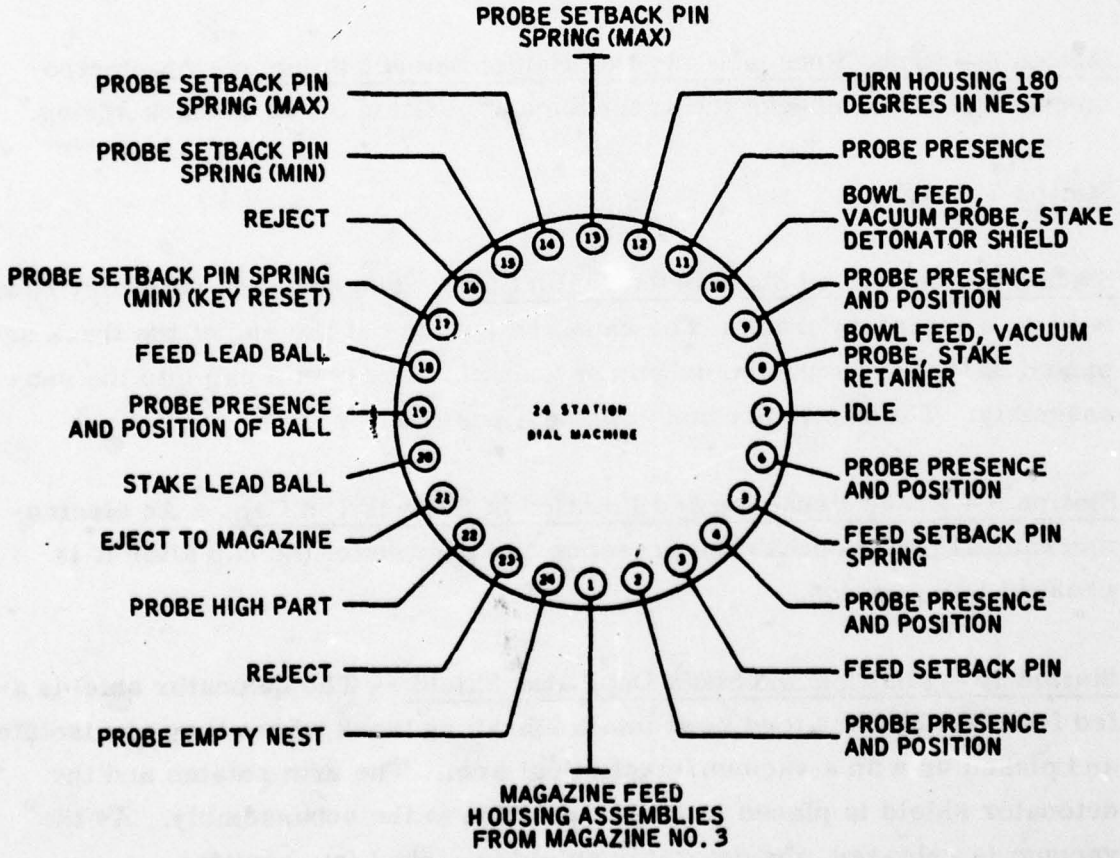


Figure 11. Machine No. 4 - Station Layout

Station 3 – Vibratory Bowl Feed Setback Pin -- Setback pins are fed into the subassembly by a vibratory feed bowl which orients the pins and discharges them into a vibratory track. The end of the track has a parts isolating mechanism which positions the pins for mechanical pickup and insertion into the subassembly.

Station 4 – Probe Presence and Position of Setback Pin -- An electromechanical probe checks for the presence and position of the setback pin the subassembly.

Station 5 – Feed Setback Spring -- Setback springs are blown from a magazine into the subassembly.

Station 6 – Probe Presence and Position of Setback Spring -- An electromechanical probe checks the presence and position of the setback spring.

Station 7 -- *Idle.*

Station 8 – Insert and Stake Setback Pin Gap -- The caps are vibratory bowl fed into a vibratory track. The caps are isolated at the end of the track and picked up with a vacuum/mechanical arm which inserts a cap into the subassembly. The cap is pressed into final position.

Station 9 – Probe Presence and Position of Setback Pin Cap -- An electromechanical probe checks the presence and position of the cap after it is pressed into position.

Station 10 – Position and Stake Detonator Shield -- The detonator shields are fed from a vibratory feed bowl into a vibratory track where they are isolated and picked up with a vacuum/mechanical arm. The arm rotates and the detonator shield is placed in proper position in the subassembly. As the vacuum is released, the detonator shield is staked into position.

Station 11 – Probe Presence and Position of Detonator Shield -- An electromechanical probe mounted on the upper tooling plate checks the presence and position of the detonator shield.

Station 12 – Invert Subassembly -- The subassembly is pressed into a pickup head which inverts the assembly 180 degrees as the tooling plate goes up. The subassembly is then returned to the nest for subsequent operations.

Station 13 – Probe Presence and Position of Subassembly -- The presence and position of the subassembly are checked to ensure that it was inverted properly.

Station 14 – Probe Setback Pin Spring (Maximum) -- A specified weighted probe mounted to the upper tooling plate checks the presence and maximum function of the setback pin spring. If the spring fails the test, the machine records this in memory and ejects the subassembly at station 16.

Station 15 – Probe Setback Pin Spring (Minimum) -- Another weighted probe checks the presence and minimum function of the setback spring. If the spring fails the test, the machine has a built-in memory which ejects the subassembly at station 16.

Station 16 – Reject Defective Subassemblies -- This station ejects all defective subassemblies into a container that have failed to pass inspection tests at stations 14 and 15.

Station 17 – Probe Setback Pin Spring (Minimum) (Redundant) -- A weighted probe again checks setback pin spring presence and maximum function.. This is a redundant probe and, if the spring fails the test, the electromechanical arm will lock in the down position. A key is required to restart the machine.

Station 18 – Feed Sealing Ball -- Sealing balls are retained in a plastic container that is oscillated with each movement of the tooling plate. The balls come from the plastic container down a tube and are metered into position.

Station 19 – Probe Presence of Sealing Ball - An electromechanical probe checks the presence and position of the ball.

Station 20 – Stake Sealing Ball - A mechanical pressing tool which is backed up with a heavy spring presses the ball into the proper position and height.

Station 21 – Eject to Magazine -- A mechanical arm picks up the subassembly and ejects it into the magazine.

Station 22 -- Idle.

Station 23 – Reject to Container -- Defective subassemblies are ejected at this station.

Station 24 – Probe Empty Nest -- The probe attached to the tooling plate checks to ensure that the nest is empty and free of parts before advancing to station 1.

MACHINE 4A – SETBACK PIN SPRING WINDER

Machine Description

The ADAM setback pin spring winder (see Figure 12) is a Sleeper and Hartley Universal spring coiler. This machine winds the setback pin spring (28102566-001) that goes into the S&A mechanism subassembly at Machine 4. One spring is wound with each cycle of the winder.

The coil-feed 0.004-inch-diameter music wire is dereeled and threaded through the tensioning device rollers to the feed roll of the winder. The wire is coiled, cut to length, and air ejected to magazines. See Table 8 for Machine No. 4A Rates.

Station Descriptions

Station 1 – Dereel -- The reel of wire is loaded onto a motor-driven shaft. The wire is threaded around 3-inch-diameter wheels attached to a slack arm. This slack arm maintains light wire tension and operates switches that turn the reel motor on and off as required to provide wire to the winder.

Station 2 – Wind Spring -- The wire is pulled into the machine through wire guides by power-driven feed rolls. It is pushed around an arbor and controlled by the coiling point and pitch tool. The resulting spring is cut off and picked up in a receiver tube and blown clear of the machine by a venturii feed air blast into a plastic transfer tube.

Station 3 – Load Springs into Magazines -- The spring magazines are loaded into a vertical stacker and indexed horizontally with a square motion drive. This motion is timed to receive a spring from the transfer tube into each magazine cavity just as the winder blows it clear. When the magazine is filled, a photocell senses its condition and operates a cross-feed to push the magazine clear for replacement by the next magazine.

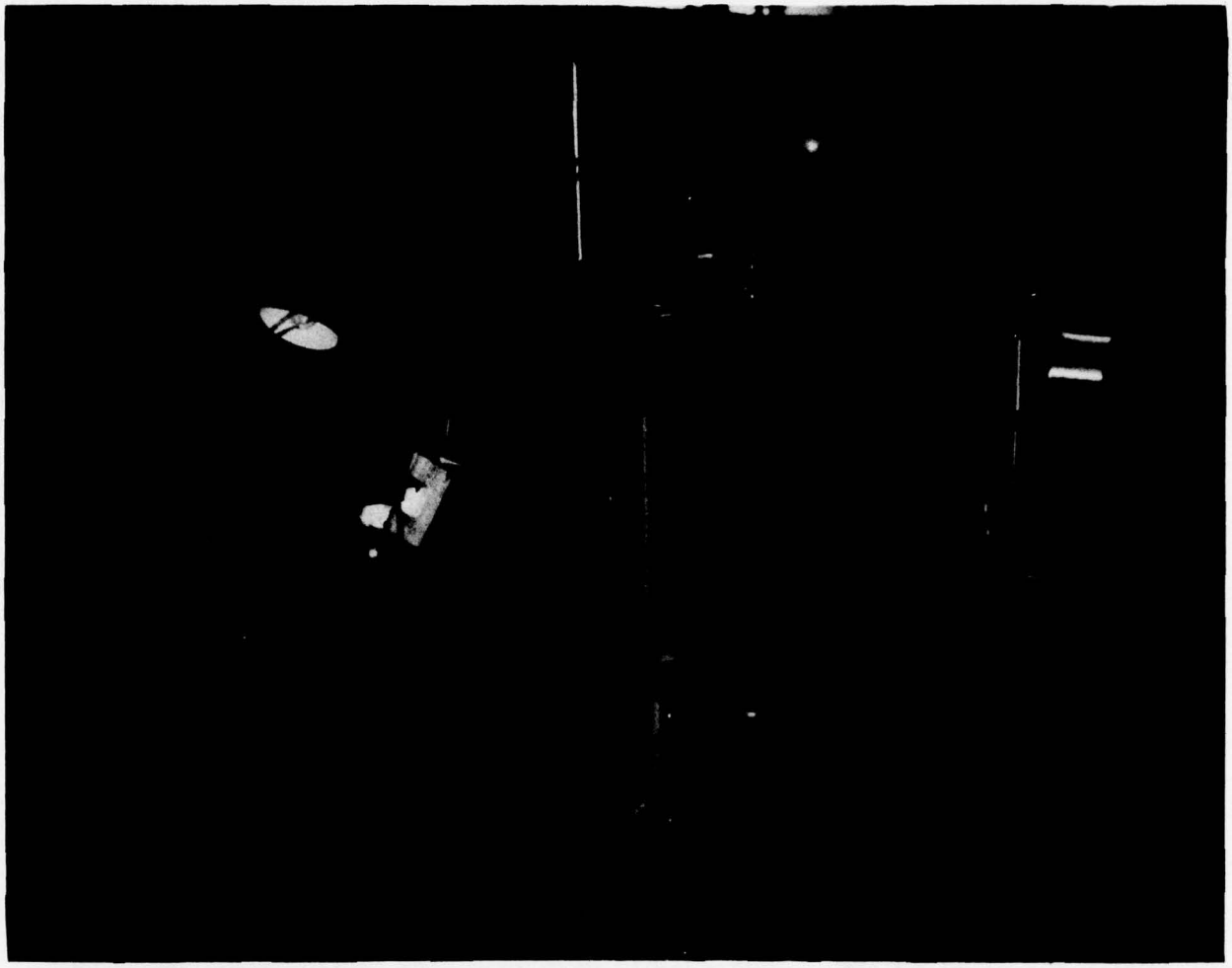


Figure 12. Machine No. 4A - Setback Pin Spring Winder

Table 8. Machine No. 4A Rates (Base Sleeper Hartley)

	Design	Actual (11/77)	
Cycles/Minute	---	---	Not Available
No. of Tools	---	---	
Average Machine Acceptance Rate per 60-Minute Hour	---	---	
Machine Accepted Assembly Rate	---%	---%	
Current Reject Rate		(1)	
Current Scrap Rate		2.5%	
(1) No machine rejection			

MACHINE 5 – S&A MECHANISM DETONATOR AND LEAD CUP ASSEMBLY

Machine Description

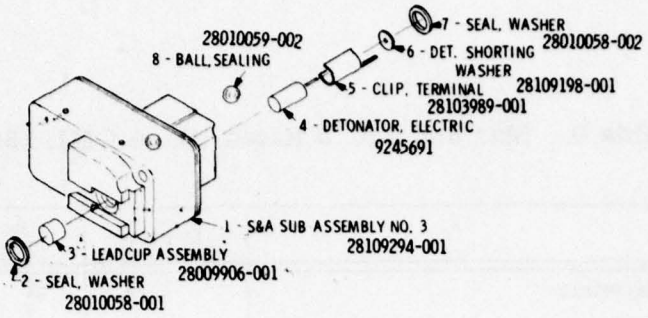
Machine 5 is a 30-station, single-nested, dial-index machine (see Figure 13). This machine starts with the S&A mechanism subassembly from Machine 4 and into it adds the electric detonator and the lead cup which are retained by seal washers. The result is the completed S&A mechanism assembly.

To accomplish this, the electric detonator is fed to the auxiliary nest followed by the addition of the terminal clip. A detonator washer is placed in position to ground the clip and the lead on the detonator. The detonator assembly is transferred to the S&A mechanism subassembly (output from Machine 4) along with two seal washers which are staked to retain the detonator assembly. The assembly is inverted so that the lead cup assembly can be inserted along with two sealing washers which are staked to hold the lead cup assembly in position.

The sealing ball is fed into the S&A mechanism and staked into place. One assembly is produced with each cycle of the machine.

The S&A mechanism subassemblies from Machine 4 and the electric detonators are magazine fed into this machine. The sealing ball is fed from a plastic container through a tube into the subassembly. The remaining parts are vibratory bowl fed.

Completed assemblies produced on this machine are placed into magazines and defective assemblies are ejected to a stub track for sorting. See Table 9 for Machine No. 5 Rates.



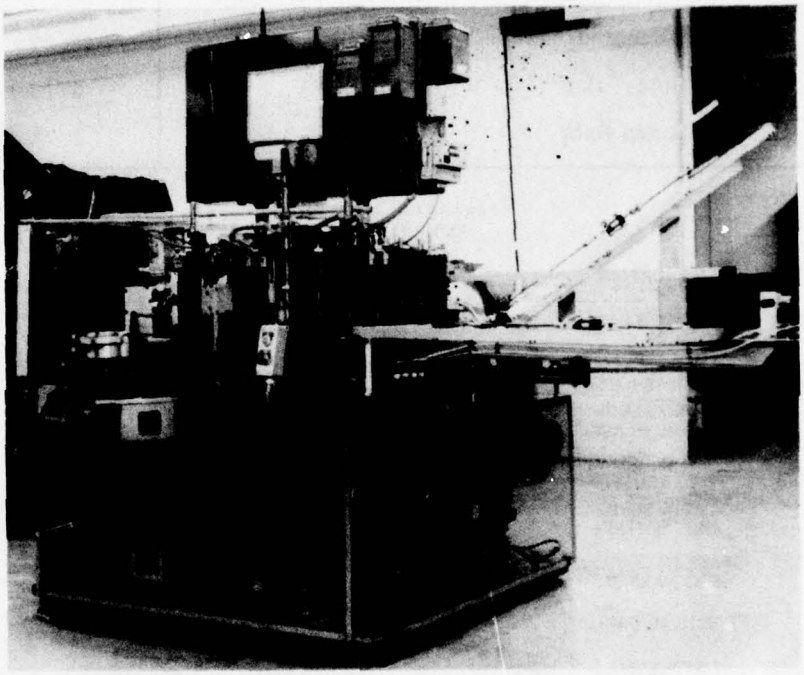


Figure 13. Machine No. 5 - S&A Mechanism Detonator and Lead Cup Assembly

Table 9. Machine No. 5 Rates (Base OML 189)

	Design	Actual (11/77)
Cycles/Minute	40	30
No. of Tools	1	1
Average Machine Acceptance Rate per 60-Minute Hour	1300	29
Machine Accepted Assembly Rate	60.2%	98.3%
Current Reject Rate		3.7%
Current Scrap Rate		1.7%

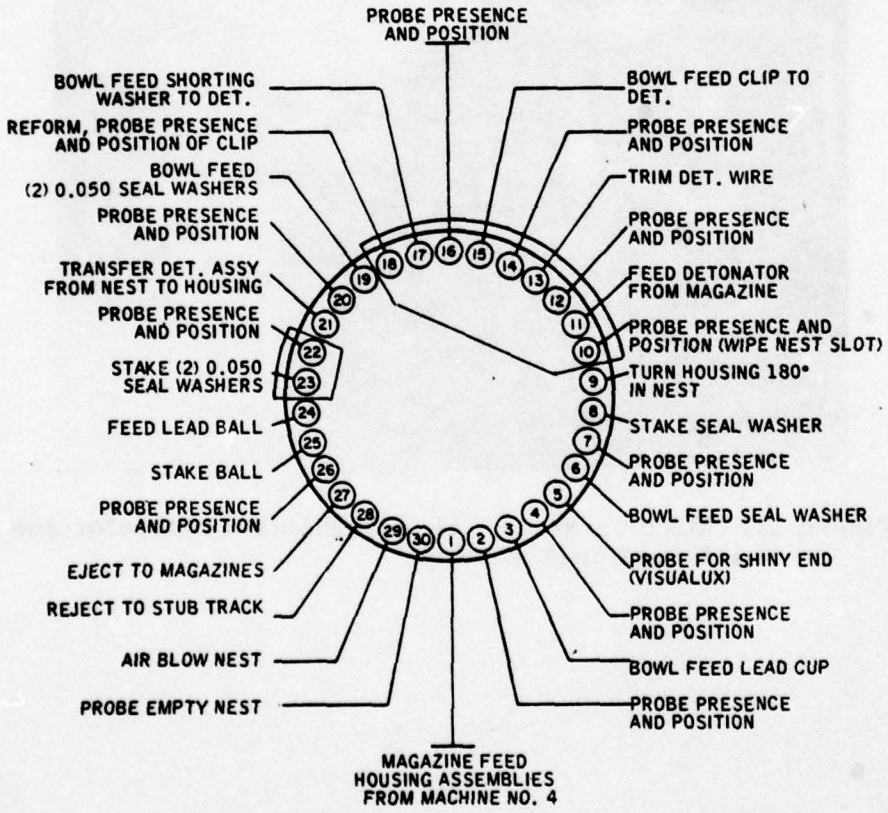


Figure 14. Machine No. 5 - Station Layout

Station Descriptions (See Figure 14)

Station 1 – Magazine Feed S&A Mechanism Subassembly from Machine 4 -- An S&A mechanism assembly produced on Machine 4 is magazine fed to a mechanical pickup which places it into the nest. (See Figure 14)

Station 2 – Probe Presence and Position -- An electromechanical probe mounted on the upper tooling plate checks the presence and position of the S&A mechanism subassembly in the nest.

Station 3 – Vibratory Bowl Feed Lead Cup -- The lead cups are vibratory bowl fed through a feed track. Just before the lead cups enter the track, they are subjected to a position check by a Visolux sensor. The green-painted end must be up or the Visolux sensor will trigger a solenoid to kick the feed cup back into the bowl. The last lead cup on the track is isolated to enable pickup and transfer into the nest.

Station 4 – Probe Presence and Position of Lead Cup -- A probe mounted to the upper tooling plate checks the presence and position of the lead cup in the subassembly.

Station 5 – Probe Position of Lead Cup -- A Visolux sensor mounted on the upper tooling plate double checks the position of the lead cup in the subassembly. The green-painted lead of the lead cup must be facing out from the subassembly.

Station 6 – Vibratory Bowl Feed Seal Washer -- Seal washers and vibratory bowl fed to a vibratory track. A mechanical 180-degree swivel pickup head is used to place the seal washer around the lead cup.

Station 7 – Probe Presence and Position of Seal Washer -- A probe mounted on the upper tooling plate checks the proper position of the seal washer around the lead cup.

Station 8 – Stake Seal Washer -- The seal washer is mechanically staked to extrude the lead washers around the lead cup. This retains the lead cup in the subassembly.

Station 9 – Invert Subassembly -- The subassembly is lifted out of the nest and rotated 180 degrees. After rotation, it is lowered back into the nest with the detonator side facing up.

Station 10 – Probe Presence and Position of Subassembly and Wipe Slot in Nest -- An electromechanical probe senses the new placement of the subassembly in the nest. At the same time, the slot in the nest for the electric detonator is wiped by a probe to ensure that nothing will interfere with the placement of the detonator.

Station 11 – Magazine Feed Electric Detonator -- Electric detonators are horizontally fed to a mechanical pickup head which sequentially picks up a detonator and places it in the small subnest. A fault at this station must be corrected before the machine will continue to cycle.

Station 12 – Probe Presence and Position of Electric Detonator -- An electromechanical probe checks for the presence and position of the electric detonator in the subnest.

Station 13 – Trim Detonator Lead Wire -- The detonator lead wire is cut off to a specified length and the cut piece is removed by a vacuum from the subnest.

Station 14 – Probe Presence and Position of Electric Detonator -- A probe mounted on the upper tooling plate probes the presence and position of the electric detonator.

SAFETY NOTE:

Because explosive components are assembled on this machine, Stations 10 through 18 are enclosed by 1/2-inch plexiglass shielding. There are three access doors in the shielding to allow the operator to load magazines of electric detonators, fill the vibratory bowl, and to correct nest problems. These access doors have microswitches to verify to the machine's memory that they are closed during operation. If a door is opened during operation of the machine, a "54" will appear on the display, and the machine will stop.

Shielding is also installed on Stations 22 and 23 to protect the operator from a possible explosion during the probe of the electric detonator in the housing or during the stake of the seal washers around the electric detonator.

Station 15 – Vibratory Bowl Feed Terminal Clip Electric Detonator -- Terminal clips are vibratory bowl fed to a vibratory track. At the end of the track, the clips are isolated and picked up with a transfer mechanism to place them over the electric detonator located in the auxiliary nest.

Station 16 – Probe Presence and Position of Terminal Clip -- An electromechenical probe mounted on the upper tooling plate probes the presence and position of the terminal clip over the electric detonator.

Station 17 – Vibratory Bowl Feed Shorting Washer to Electric Detonator -- Shorting washers are vibratory bowl fed to a vibratory feed track. At the end of the track, the washers are isolated and a pneumatic/mechanical tool places a shorting washer over the electric detonator lead. This forms a short between the detonator lead and the terminal clip to ensure safe handling in subsequent operations.

Station 18 – Reform Terminal Clip and Probe Presence and Position of Electric Detonator -- A probe simultaneously reforms the terminal clip to captivate the shorting washer and also checks the presence and position of the shorting washer.

Station 19 – Vibratory Bowl Feed Two Seal Washers -- The seal washers are bulk loaded into two vibratory feed bowls which orient and discharge them from each bowl to a common pickup head. The washers are aligned vertically and placed into the subassembly in the nest.

Station 20 – Probe Presence and Position of Seal Washers -- A probe checks for the proper presence and position of the seal washers in the subassembly.

Station 21 – Transfer Detonator Assembly from Subnest into Subassembly -- A mechanical transfer tool picks up the detonator assembly from the auxiliary nest and moves it into the proper position in the subassembly. An

electromechanical probe mounted on the upper tooling plate checks the presence and position of the detonator assembly in the subassembly.

Station 22 – Probe Presence and Position of Detonator Assembly -- A probe checks to ensure that the detonator assembly is properly transferred.

Station 23 – Stake Two Seal Washers -- A weight stake is used to extrude two seal washers around the electric detonator to retain the detonator assembly.

Station 24 – Feed Sealing Ball -- A sealing ball is fed through a hose to the nest where it is placed in the barrier support pin hole.

Station 25 – Stake Sealing Ball -- A weight stake is used to flatten and extrude the sealing ball which seals the barrier support pin hole in the subassembly.

Station 26 – Probe Presence and Position of Staked Sealing Ball -- A probe checks the pressed condition of the sealing ball to ensure that the stake height is maintained.

Station 27 – Eject to Magazine -- A mechanical pickup tool is used to lift the acceptable S&A mechanism assemblies from the nest. These assemblies are moved horizontally into an extruded aluminum magazine.

Station 28 – Reject to Stub Track -- A mechanical pickup tool is used to lift the rejected assemblies from the nest. It moves them horizontally to a stub track which is shielded with plexiglas. When the stub track is filled, the operator transfers the contents to an explosive container.

Station 29 – Air Blow Nest -- An air tube is directed at the empty nest to blow away any foreign material from the nest and subnest.

Station 30 – Probe Empty Nest -- This probe checks to ensure that the nest is empty of assemblies and parts before starting the next cycle at station 1.

MACHINE 7 – SENSOR BOBBIN ASSEMBLY

Machine Description

Machine 7 is a 16-station, dual-nested, dial-index machine (see Figure 15). The machine was originally planned to be quadruple nested, and the carousel is built to accommodate quadruple nesting. However, when the machine was placed in production, it was learned that it is more practical to utilize only two sets of nests because the feeding is more reliable.

This machine winds the thread on the bobbins (two at a time) and applies tape to the front side of the bobbin to retain the thread.

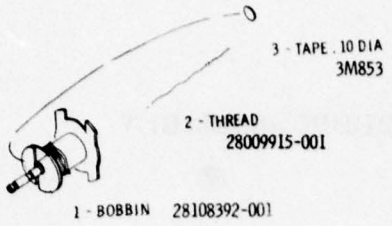
The bobbins are fed through a vibratory feed bowl and the thread is guided through tensioners from spools. The tape is received in rolls and is punched out and transferred to the bobbin. To improve the curing of the adhesive on the tape, a station has been added which applies heat to the punched out tape. The thread is cut and the scrap ends are picked up by a vacuum. All assemblies are ejected into containers at station 14. See Table 10 for Machine No. 7 Rates.

Station Descriptions (See Figure 16)

Station 1 – Vibratory Bowl Feed, Orient, and Load Bobbin -- A vibratory feed bowl orients and discharges the bobbins into a feed track. A metering device isolates the last bobbin in the track which is fed into the oriented nest.

Station 2 -- Idle.

Station 3 – Probe Presence and Position of Bobbin -- An electromechanical probe checks the presence and position of the bobbin.



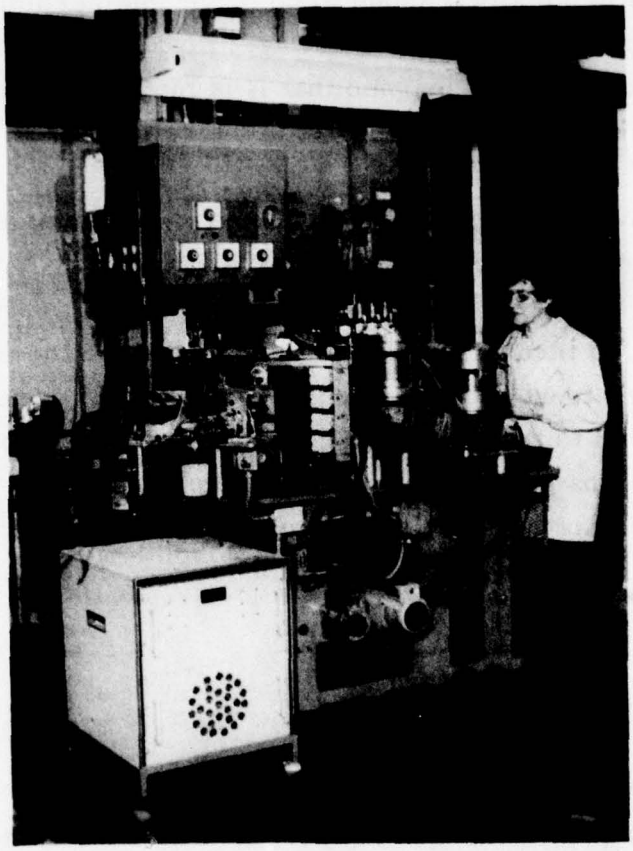


Figure 15. Machine No. 7 - Sensor Bobbin Assembly

Table 10. Machine No. 7 Rates (Base OML 304)

	Design	Actual (11/77)
Cycles/Minute	9	5.45
No. of Tools	4	2
Average Machine Acceptance Rate per 60-Minute Hour	1300	387
Machine Accepted Assembly Rate	60.2%	81.0%
Current Reject Rate		4.0% (1)
Current Scrap Rate		4.0% (1)
(1) No salvage		

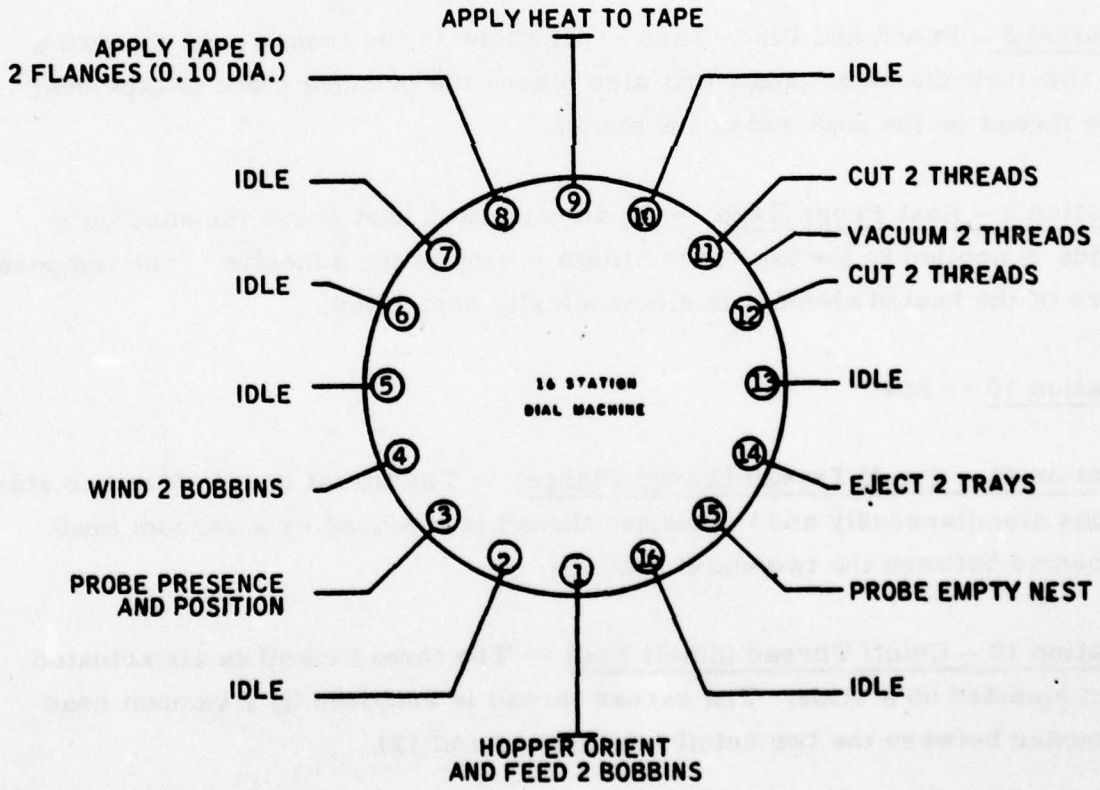


Figure 16. Machine No. 7 - Station Layout

Station 4 – Wind Thread on Bobbin -- Approximately 330 turns of thread are wound onto the bobbin and the number of turns is counted electronically. The flier, which controls the lay of the thread, is oscillated with a cam mounted to the winding head. When the winding of the bobbin is complete, the winding head retracts and wraps three turns of thread around the post end of the bobbin. Proper tension must be maintained on the thread as it continues to carry through the subsequent stations.

Station 5 – Idle.

Station 6 – Idle.

Station 7 – Idle.

Station 8 – Punch and Place Tape -- The tape is fed from a reel through a 0.100-inch-diameter punch that also places the punched piece of tape over the thread on the post end of the bobbin.

Station 9 – Heat Press Tape -- An air-operated heat press mounted on a slide is applied to the tape to facilitate curing of the adhesive. The temperature of the heated element is electronically controlled.

Station 10 -- Idle.

Station 11 – Cutoff Thread (Large Flange) -- The threat is cut off at two stations simultaneously and the excess thread is removed by a vacuum head mounted between the two cutoff stations.

Station 12 – Cutoff Thread (Small End) -- The thread cutoff is air actuated and mounted on a slide. The excess thread is removed by a vacuum head mounted between the two cutoff (stations 11 and 12).

Station 13 -- Idle.

Station 14 – Eject to Container -- The sensor bobbin and thread assemblies are ejected by an air-actuated piston which retracts the spring pin in the nest. Assemblies are then dispensed to a chute which empties into a container.

Station 15 – Probe Empty Nest -- An electromechanical probe check to ensure that the bobbin assembly has been ejected from the nest before repeating the cycle.

Station 16 -- Idle.

MACHINE 8 – DIAPHRAGM ASSEMBLY

Machine Description

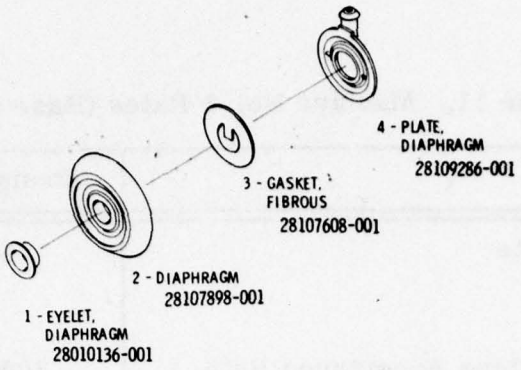
Machine 8 is a 20-station, dual-nested, dial-index machine (see Figure 17). This machine assembles the diaphragm assembly which consists of a diaphragm plate, fibrous gasket, diaphragm, and an eyelet. The eyelet is crimped to hold the assembly together. Two assemblies are produced with each cycle of the machine.

The diaphragm plates and eyelets are fed to the machine by a vibratory feed bowl. The diaphragms are fed to the machine by a magazine and the gaskets are blanked out complete from a roll of material on the machine. Completed assemblies are placed into magazines and defective assemblies are rejected to a container. See Table 11 for Machine No. 8 Rates.

Station Descriptions (See Figure 18)

Station 1 – Vibratory Feed Two Diaphragm Plates -- The vibratory feed bowl orients the diaphragm plates and discharges them to a horizontal vibratory track. The track feeds the plates to a shuttle which locates the last two plates at the end of the track in preparation for pickup. A horizontal transfer mechanism picks up the two plates and transfers them into the nest.

Station 2 – Probe Presence and Position of Diaphragm Plates (Nest A) -- An electromechanical probe mounted to the upper tooling plate probes the presence and position of the diaphragm plate that has been fed at station 1, Nest A.



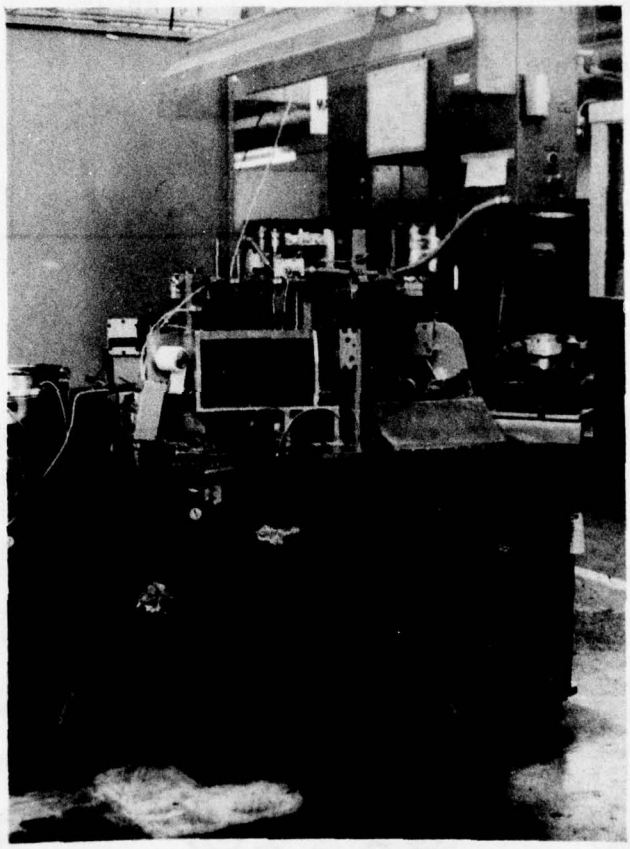


Figure 17. Machine No. 8 - Diaphragm Assembly

Table 11. Machine No. 8 Rates (Base OML 315)

	Design	Actual (11/77)
Cycles/Minute	50	28
No. of Tools	2	2
Average Machine Acceptance Rate per 60-Minute Hour	3000	863
Machine Accepted Assembly Rate	69.4%	83.1%
Current Reject Rate		1.4%(1)
Current Scrap Rate		1.4%(1)
(1) No salvage		

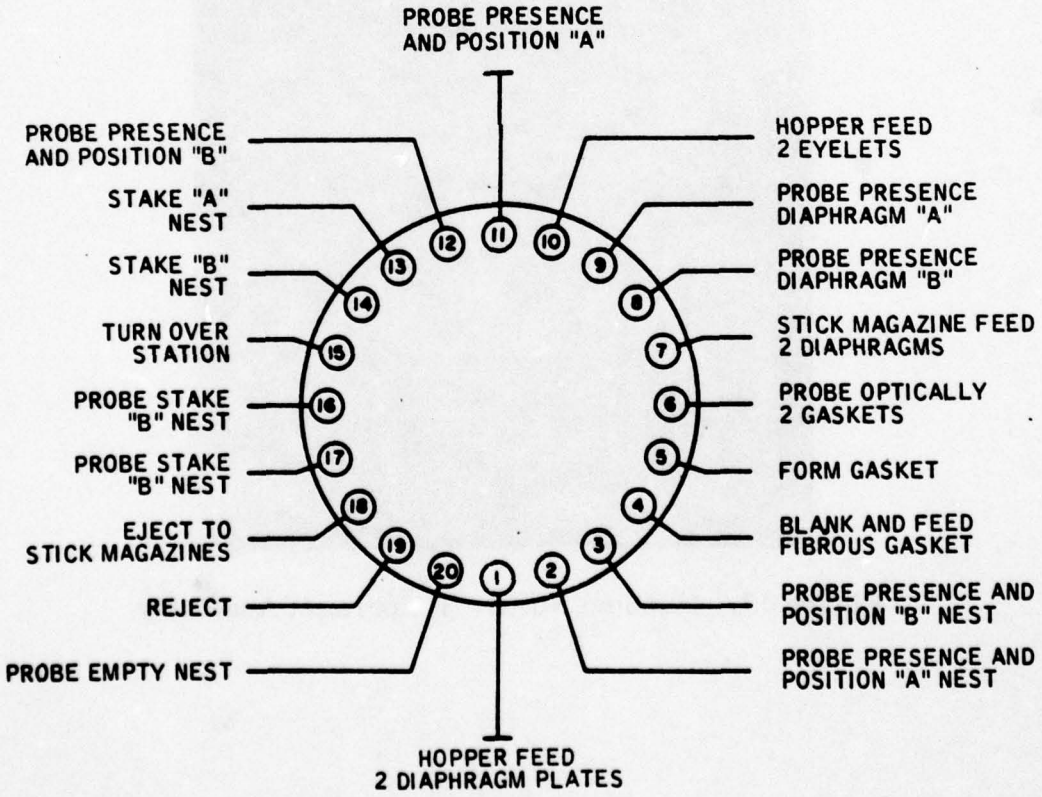


Figure 18. Machine No. 8 - Station Layout

Station 3 – Probe Presence and Position of Diaphragm Plates (Nest B) -- An electromechanical probe mounted to the upper tooling plate probes the presence and position of the diaphragm plate fed at station 1, Nest B.

Station 4 – Blank and Feed Fibrous Gasket -- The fibrous gasket material is supplied in roll form and kept in a special closed container with a dessicant until used on the machine.

The roll is fed through an air-operated four-station die. Stations 4-1A and 4-1B blank out the center openings as scrap. Stations 4-2A and 4-2B blank through the material and place the gaskets into both dial nests (A and B). The gaskets are held onto the end of the punches during transfer by a vacuum.

Station 5 – Form Gasket -- The center areas of the gasket are formed downward by conical-shaped probes attached to the upper tooling plate. This preforming of the gaskets helps hold them in position as they traverse around the dial into the assembly.

Station 6 – Optically Probe Two Gaskets -- Two photoreflective sensors are mounted at the end of a probe attached to the upper tooling plate. If the light-colored gaskets are in place and properly positioned, the sensors will detect the reflected light.

Station 7 – Magazine Feed Two Diaphragms -- Diaphragms are supplied to the machine in stick magazines. A cam-operated transfer mechanism picks up the two diaphragms with a vacuum and places them into the nests (A and B). The magazine is advanced twice by an air-powered square-motion mechanism so that two diaphragms are available for the assembly period.

Station 8 – Probe Presence and Position of Diaphragm (Nest B) -- An electromechanical probe mounted to the upper tooling plate probes the presence and position of the diaphragm (Nest A).

Station 9 – Probe Presence and Position of Diaphragm (Nest A) -- An electromechanical probe mounted to the upper tooling plate probes the presence and position of the diaphragm (Nest A).

Station 10 – Vibratory Bowl Feed Two Eyelets -- This vibratory bowl orients and feeds two eyelets to a double row, inclined track. At the end of the track, a shuttle isolates the two eyelets to a pocket to accommodate the transfer mechanism. The horizontal transfer mechanism picks up the two eyelets and inserts them into the assemblies in the two nests.

Station 11 – Probe Presence and Position of Eyelet (Nest A) -- An electromechanical probe mounted to the upper tooling plate probes the presence and position of the eyelet assembled at station 10, Nest A.

Station 12 – Probe Presence and Position of Eyelet (Nest B) -- An electromechanical probe mounted to the upper tooling plate probes the presence and position of the eyelet assembled at station 10, Nest B.

Station 13 – Stake Eyelet (Nest A) -- An air-operated toggle backs up the eyelet from above while an air-powered anvil comes up through the bottom of the dial and stakes the eyelet.

Station 14 – Stake Eyelet (Nest B) -- An air-operated toggle backs up the eyelet from above while an air-powered anvil comes up through the bottom of the dial and stakes the eyelet.

Station 15 – Turn Parts Over -- This station turns the parts over and places them back into the nest, part A to nest B and part B to nest A.

Station 16 – Probe Stake (Nest B) -- This probe is mounted to the upper tooling plate and has a ball end that rests in the staked end of the eyelet and a flat surface used as a gaging datum. A cam-operated probe contacts the eyelet from below and a measurement is made.

Station 17 – Probe Stake (Nest A) -- A probe mounted to the upper tooling plate has a ball end that rests in the stake end of the eyelet and a flat surface as a gaging datum. A cam-operated probe contacts the eyelet and from below a measurement is made.

Station 18 – Eject to Stick Magazine -- Acceptable diaphragm assemblies ejected to a stick magazine. A transfer mechanism picks the assemblies out of the nest and transfers them to the magazines.

Station 19 – Reject to Container -- A cam-operated probe comes up through nests A and B and lifts the defective assemblies out of the nests. These assemblies are air blown into a reject container.

Station 20 – Probe Empty Nest -- An electromechanical probe mounted on the upper tooling plate checks to ensure that both nests A and B are completely empty and free of loose parts.

MACHINE 9 – TUBE/HOUSING ASSEMBLY

Machine Description

Machine 9 is a 20-station, dual-nested, dial-index machine (see Figure 19). This machine assembles the housing tube (28110958-001) to the housing cup (28111103-001) and stakes the two parts together to form the tube/housing assembly (28109134-001). Two assemblies are produced with each cycle of the machine.

The housing tubes and cups are feed to the machines by vibratory feed bowls. Completed assemblies are ejected to bins and defective assemblies are rejected to separate containers. See Table 12 for Machine No. 9 Rates.

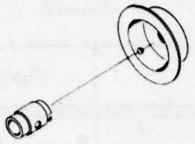
Station Descriptions (See Figure 20)

Station 1 – Vibratory Bowl Feed Housing Tube into the A Nest -- Housing tubes are delivered from a vibratory feed bowl into a vibratory track which feeds through a plastic tube. At the end of the tube, a meter isolates the lowest tube which falls into a gravity feed tube.

Station 2 – Vibratory Bowl Feed Housing Tube into the B Nest -- The function of this station is identical to that described for station 1 except that the housing tubes are fed into the B nest.

Station 3 – Probe Presence and Position of Housing Tube (Nest A) -- An electromechanical probe mounted on the upper tooling plate checks the presence and position of the tube in nest A. If the tube is missing or misoriented, the tooling plate will elevate to the up position and stop the machine.

Station 4 -- Idle.



2 - CUP, HOUSING
28111103-001

1 - TUBE, HOUSING
28110958-001

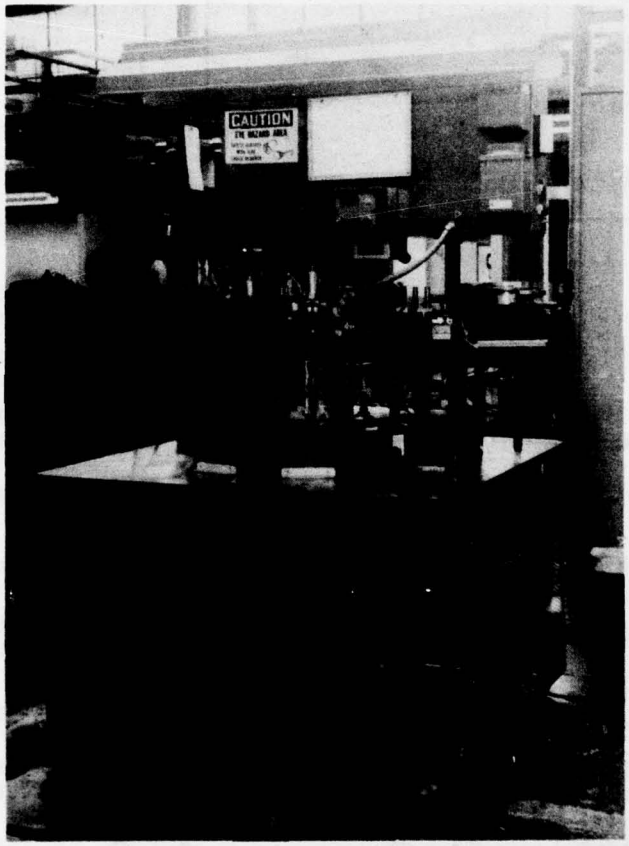


Figure 19. Machine No. 9 - Tube/Housing Assembly

Table 12. Machine No. 9 Rates (Base OML 315)

	Design	Actual (11/77)
Cycles/Minute	50	24
No. of Tools	2	2
Average Machine Acceptance Rate per 60-Minute Hour	3000	1223
Machine Accepted Assembly Rate	69.4%	97.1%
Current Reject Rate		0.3%(1)
Current Scrap Rate		0.3%(1)
(1) No salvage		

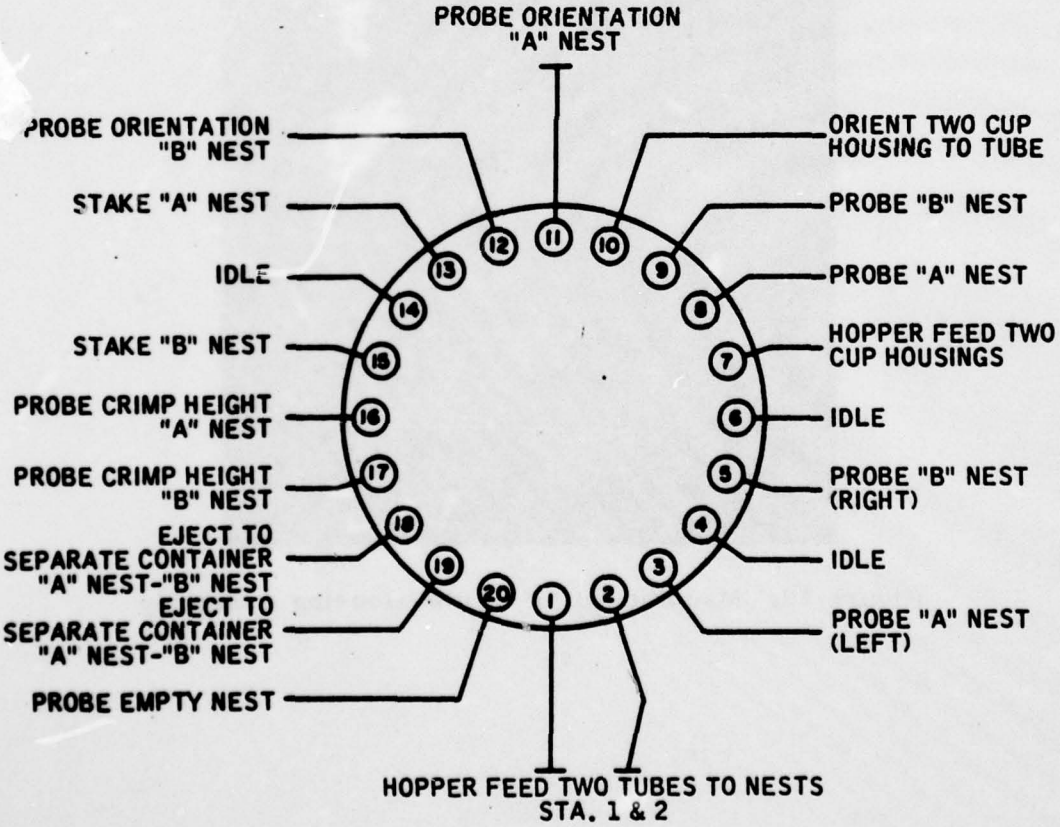


Figure 20. Machine No. 9 - Station Layout

Station 5 – Probe Presence and Position of Housing Tube (Nest B) -- An electromechanical probe mounted on the upper tooling plate checks the presence and position of the tube in nest B. If the tube is missing or misoriented, the tooling plate will elevate to the up position and stop the machine.

Station 6 -- Idle.

Station 7 – Hopper Feed Two Housing Cups -- Cup housings are fed by a vibratory feed bowl which orients the cups and discharges them into a dual gravity feed track. A shuttle isolates the bottom cups on each track and a mechanical pickup removes the cups and places them into the nest over the housing tube.

Station 8 – Probe Presence and Position of Housing Cup (Nest A) -- An electromechanical probe checks to ensure that the cup housing in nest A is present and properly positioned. If the cup is missing or misoriented, the tooling plate will elevate to the up position and stop the machine.

Station 9 – Probe Presence and Position of Housing Cup (Nest B) -- An electromechanical probe checks to ensure that the cup housing in nest B is present and properly positioned. If the cup is missing or misoriented, the tooling plate will elevate to the up position and stop the machine.

Station 10 – Orient Two Housing Cups to Housing Tubes -- An electrically driven motor turns the two orient heads simultaneously. Rubber cushioned tips on the heads turn the cup housings until the two tabs in the center hole fall into the two slots in the housing tubes.

Station 11 – Probe Orientation (Nest A) -- An electromechanical probe checks to ensure that the housing cup is properly oriented to the housing tube and that the overall height is correct.

Station 12 – Probe Orientation (Nest B) -- An electromechanical probe checks to ensure that the housing cup is properly oriented to the housing tube and that the overall height is correct.

Station 13 – Stake Assembly (Nest A) -- When the upper tooling plate drops down to the dial, a two-fingered hold-down arm is positioned over the flange on the housing cup. This secures the assembly while the timed firing of an air cylinder drives the staking head down to stake the tube over the cup.

Station 14 -- Idle.

Station 15 – Stake Assembly (Nest B) -- When the upper tooling plate drops down to the dial, a two-fingered hold-down arm is positioned over the flange on the housing cup. This secures the assembly while the timed firing of an air cylinder drives the staking head down to stake the tube over the cup.

Station 16 – Probe Height of Crimp (Nest A) -- An electromechanical probe mounted on the upper tooling plate checks the height of the crimped assembly.

Station 17 – Probe Height of Crimp (Nest B) -- An electromechanical probe mounted on the upper tooling plate checks the height of the crimped assembly.

Station 18 – Eject to Container (Nests A and B) -- When the upper tooling plate lowers to the down position, a shroud covers both nests A and B and a timed air blast blows both the assemblies through the shroud and into separate containers.

Station 19 – Reject to Container (Nests A and B) -- This station functions the same as station 18 except that the rejected assemblies are blown into the container.

Station 20 – Probe Empty Nest -- An electromechanical probe checks to ensure that assemblies and foreign material have been cleared out of the nest before allowing the machine to repeat the cycle at station 1.

MACHINE 10 – SENSOR RELEASE MECHANISM ASSEMBLY

Machine Description

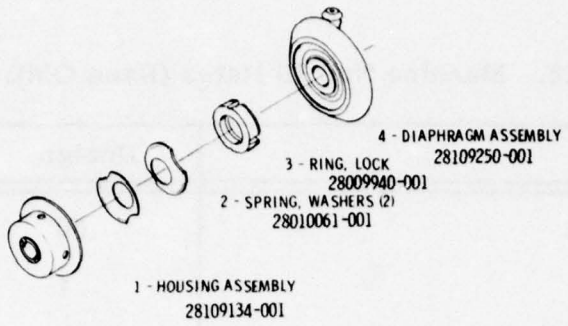
Machine 10 is a 20-station, single-nested, dial-index machine (see Figure 21). This machine assembles the diaphragm assembly from Machine 8, the tube/housing assembly from Machine 9, two spring washers, and the lock ring. The springs are exercised three times after being assembled and the spring rate is checked. The diaphragm assembly is fed, pre-staked, and crimped to the tube/housing assembly to hold the assembly together. One assembly is produced with each cycle of the machine.

The tube/housing assembly from Machine 9 and the lock ring are vibratory bowl fed. The springs are picked up by a vacuum from stick magazines. These stick magazines are loaded onto the machine from a vibratory feed bowl. The diaphragm assembly from Machine 8 is magazine fed. Completed assemblies are placed into magazines and defective assemblies are ejected into a container. See Table 13 for Machine No. 10 Rates.

Station Descriptions (See Figure 22)

Station 1 – Hopper Feed Tube/Housing Assembly from Machine 9 -- The tube/housing assembly from Machine 9 is vibratory bowl fed and discharged to a gravity feed track. The assemblies are metered at the end of the track where a pickup head mechanically deposits the assembly into the nest.

Station 2 – Orient Tube/Housing Assembly -- An electric motor turns a cushioned orient head mounted on the upper tooling plate. When the head contacts the tube/housing assembly, it rotates the assembly until a small hole in the cup housing of the assembly drops over a pin in the nest cavity. At this point, the clutch assembly in the rotating orient head will slip until the cycle is completed.



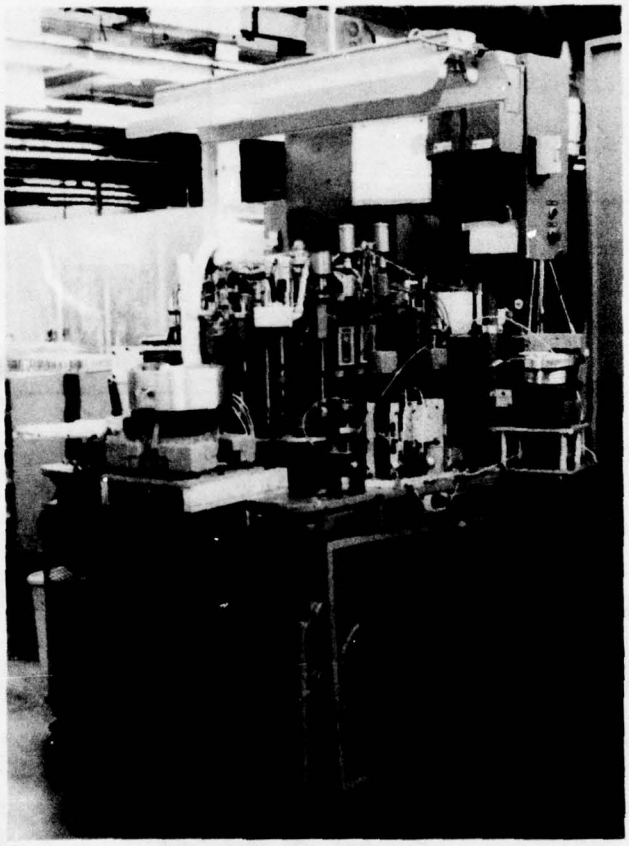


Figure 21. Machine No. 10 - Sensor Release Mechanism Assembly

Table 13. Machine No. 10 Rates (Base OML 315)

	Design	Actual (11/77)
Cycles/Minute	50	24
No. of Tools	1	1
Average Machine Acceptance Rate per 60-Minute Hour	1500	402
Machine Accepted Assembly Rate	69.4%	80.9%
Current Reject Rate		5.0%
Current Scrap Rate		0.7%

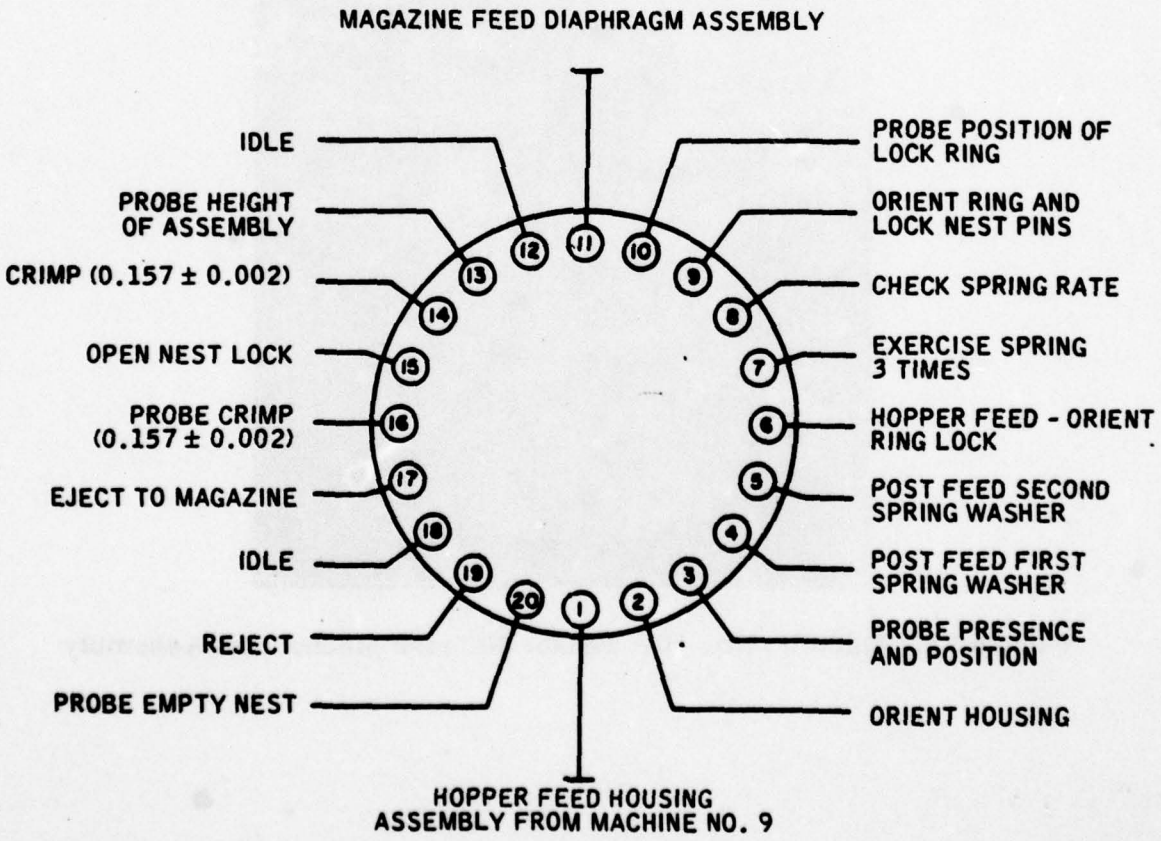


Figure 22. Machine No. 10 - Station Layout

Station 3 – Probe Presence and Position of Tube/Housing Assembly -- A photo-electric light source and receiver are mounted on the upper tooling plate. When the tooling plate comes down, this photo-electric sensor positions itself on each side of the nest. If the tube/housing assembly is properly oriented, two holes in the housing cup of the assembly and two holes in the housing tube or the assembly should be aligned so that the light will pass through. This photo-optic probe checks not only orientation, but performs a double check of the assembly from Machine 9.

Station 4 – Post Feed First Spring Washer -- Formed spring washers are loaded onto stick magazines from an external vibratory feed bowl not mounted on the machine. The filled stick magazines are transferred to the machine by the operator at this station. A vacuum head on a swing arm picks a spring washer out of the stack, rotates to a position over the nest, and deposits it in the tube/housing assembly. As the stack diminishes, a motor-operated screwdrive maintains a constant level of the washers on the stick magazine.

Station 5 - Post Feed Second Spring Washer -- The operation of this station is precisely the same as that described for station 4. The only differences are that the radius of the spring is down at this station and up at station 4 and rotated 90 degrees to the spring of station 4.

Station 6 - Hopper Feed and Orient Ring Lock -- The lock rings are vibratory bowl fed and discharged to a gravity feed track. A parts isolator feeds one ring lock at a time into the mechanical pickup head.

Station 7 - Exercise Spring Three Times -- A mechanical probe mounted on the upper tooling plate lowers onto the lock ring. When the probe reaches a certain position, it trips a microswitch mounted on the upper tooling plate which fires an air cylinder three times.

Station 8 – Check Spring Rate -- This probe has a fixed weight which depresses the springs within a given range. This range variation is detected with an electrocator.

Station 9 – Orient Ring Lock and Position Nest Pin -- The grooves in the lock ring are oriented while the ring is being pressed down against the spring pressure. Simultaneously, the nest pins are engaged to retain the parts in a compressed condition.

Station 10 – Probe Position of Lock Rings -- An electromechanical probe mounted on the upper tooling plate checks the presence and position of the lock ring.

Station 11 - Magazine Feed Diaphragm Assembly -- A mechanical pickup head with air-operated jaws picks the diaphragm assembly out of a magazine, elevates it, and transfers it into the nest.

Station 12 -- Idle.

Station 13 – Probe Height of Assembly -- An electromechanical probe mounted on the upper tooling plate probes the height of the assembly.

Station 14 – Stake Assembly -- A timed air cylinder works through a mechanical linkage and forces the staking head down on the assembly. This stake head has a compound action which holds the assembly in position while the internal staking punch performs the stake.

Station 15 – Open Nest Pins -- Two mechanical fingers are lowered over the ends of the nest lock pins and the actuation of an air cylinder spreads the fingers apart, retracting the nest lock pins.

Station 16 – Probe Stake -- An electrocator probe mounted on the upper tooling plate checks the height of the staked assembly.

Station 17 – Eject to Magazine -- A mechanical pickup head mounted on the upper tooling plate picks up and transfers the completed assembly from the nest to the magazine.

Station 18 -- Idle.

Station 19 – Clean Nest -- As the upper tooling plate lowers, a vacuum hose attached to it vacuums the nest clean of parts and assemblies.

Station 20 – Probe Empty Nest -- An electromechanical probe checks to ensure that the nest is free of all parts, assemblies, or foreign material before continuing to cycle to station 1.

MACHINE 11 – SENSOR RELEASE MECHANISM AND CASE ASSEMBLY

Machine Description

Machine 11 is a 20-station, single-nested, dial-index machine (see Figure 23). This machine assembles the sensor release mechanism and case assembly. The sleeve, sensor case, case washer, four locking balls, and the completed sensor release mechanism assembly from Machine 10A are assembled to make up the sensor release mechanism and case assembly.

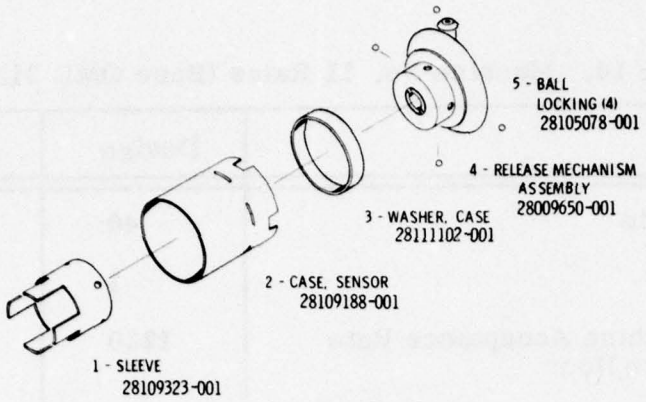
The nests on this machine have a compounding feature which captivate the assembly and include a rotating feature that enables the four balls to be probed prior to positioning within the assembly. The case is crimped to hold the assembly together.

One assembly is produced with each cycle of the machine.

The sleeve, case, and washer are vibratory bowl fed. The sensor release mechanism assembly from Machine 10 is magazine fed, and the four balls are picked up by a vacuum from an open container. Completed assemblies are placed into magazines and defective assemblies are rejected to a container. See Table 14 for Machine No. 11 Rates.

Station Descriptions (See Figure 24)

Station 1 – Orient and Vibratory Bowl Feed Sleeve to Nest -- This station orients the sleeve in a vibratory feed bowl and feeds the parts to a gravity feed track. A parts isolator at the bottom of the track separates one sleeve and holds it in position for pickup and transfer to the nest.



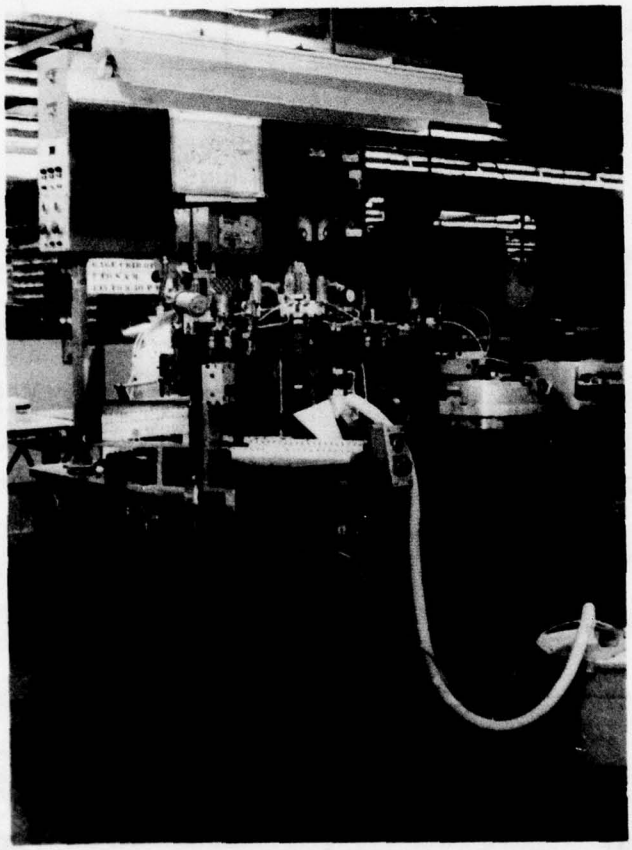


Figure 23. Machine No. 11 - Sensor Release Mechanism and Case Assembly

Table 14. Machine No. 11 Rates (Base OML 315)

	Design	Actual (11/77)
Cycles/Minute	40	26
No. of Tools	1	1
Average Machine Acceptance Rate per 60-Minute Hour	1250	393
Machine Accepted Assembly Rate	69.4%	97.1%
Current Reject Rate		4.0%
Current Scrap Rate		3.0%

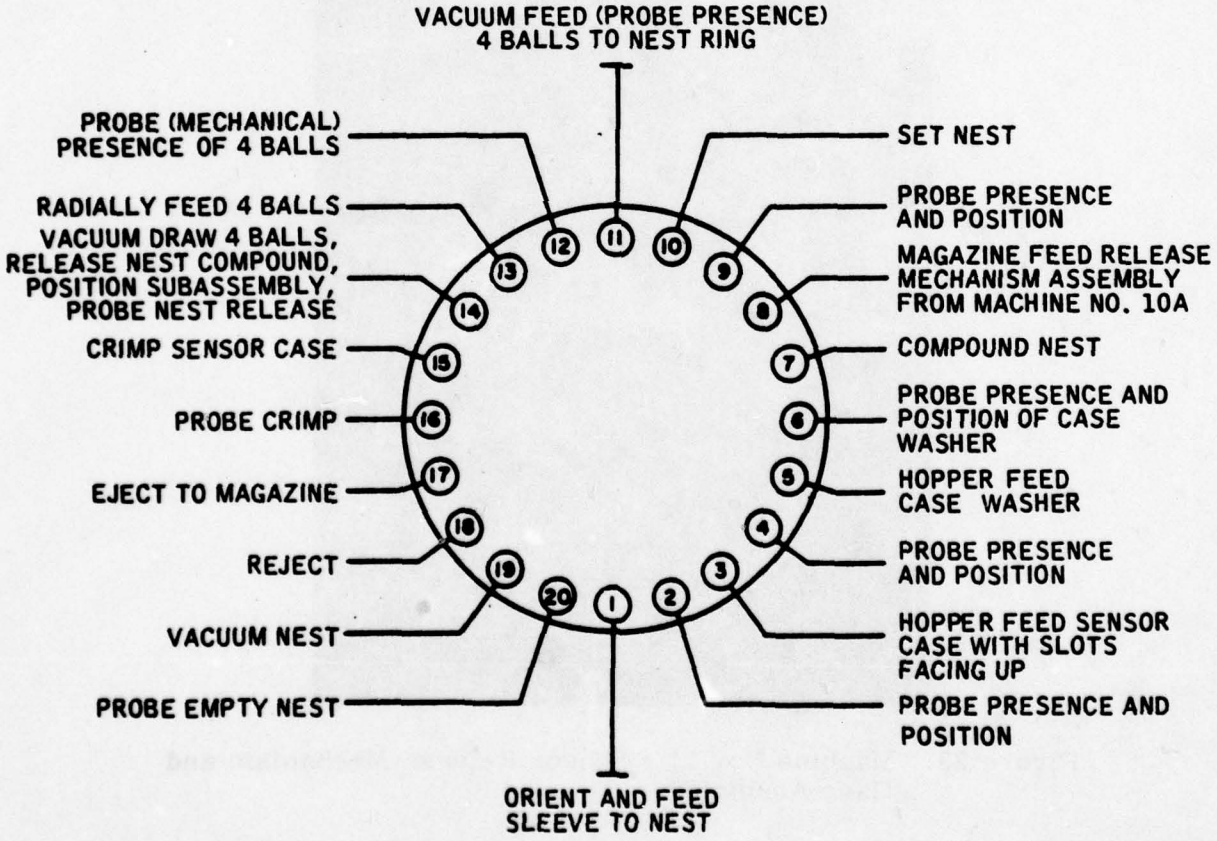


Figure 24. Machine No. 11 - Station Layout

Station 2 – Probe Presence and Position of Sleeve -- The probe station is mounted to the upper tooling plate and checks for the presence and proper position of the sleeve in the nest.

Station 3 – Vibratory Bowl Feed Sensor Case -- The sensor cases are oriented in a vibratory bowl which feeds to a gravity feed track. A shuttle at the bottom of the track isolates a sensor case for transfer into the nest.

Station 4 – Probe Presence and Position of Sensor Case -- This probe checks to ensure that the sensor case is present and in the proper position.

Station 5 – Hopper Feed Case Washer -- This station orients the washer in the vibratory feed bowl and discharges into a gravity feed track. At the end of the track, a transfer mechanism picks up the washer and transfers it to the nest.

Station 6 – Probe Presence and Position of Case Washer -- An electromechanical probe is mounted to the upper tooling plate and checks for the presence and proper position of the case washer in the subassembly.

Station 7 – Compound Nest -- When the dial indexes a nest into position at this station, the center pin of the nest is no longer supported by the rail under the dial. As the tooling plate is lowered, the arm and its tooling push the sensor case, sleeve, and case washer down into the compound nest. The nest and subassembly are now ready to accept the sensor release mechanism assembly.

Station 8 – Magazine Feed Sensor Release Mechanism Assembly from Machine 10A -- Sensor release mechanism assemblies are received from Machine 10A on magazines. The magazines are loaded in a vertical stacker from which magazines are indexed to allow feeding one assembly at a time for transfer into the nest.

Station 9 – Probe Presence and Position of Sensor Release Mechanism Assembly -- This probe station, mounted to the upper tooling plate, checks to ensure that the sensor release mechanism assembly is in presence and properly positioned.

Station 10 – Set Nest -- This station ensures that the nest and subassembly are set at the proper height to accept the four balls that will be loaded at the next station.

Station 11 – Vacuum Feed Four Balls to Nest Ring -- This station picks up four demagnetized balls at the same time with a vacuum and simultaneously checks for the presence of all four balls by monitoring the differential of vacuum. The four balls are transferred to four separate cavities in the nest.

Station 12 – Probe Presence of the Four Balls -- This probe station has four contact points which must be satisfied by the presence of the four balls. If any of the four balls are missing, the machine will stop and the condition must be corrected before the machine will restart.

STATION 13 – Radially Feed Four Balls -- This station is mounted to the tooling plate. As the tooling plate comes down, the tooling head cams the nest ring radially and releases the four balls. They drop down the ramps in the nest and enter the release mechanism assembly.

STATION 14 – Vacuum Draw Four Balls, Release Nest Compound, Position Subassembly, and Probe Nest Release -- This station performs four operations on the nest. As the tooling plate descends, a vacuum probe seals on the nest and draws the four balls into the sensor release mechanism assembly. When the tooling plate is all the way down, an air cylinder lowers tooling on top of the nest to release the nest compound. At the same time, a cam-operated rod hits the center pin of the nest and pushes the subassembly upwards in the nest. When the dial indexes the nest, a microswitch probes the center pin of the nest ensure that the compound nest has released.

Station 15 – Crimp Sensor Case -- The sensor case is crimped to retain the sensor release mechanism assembly and case washer inside the assembly.

Station 16 – Probe Crimp -- This probe station checks to ensure that the crimp has been accomplished to the proper height.

Station 17 – Eject to Magazine -- Assemblies that have satisfied the probe at station 16 are picked up by the transfer mechanism and unloaded into magazines.

Station 18 – Reject to Container -- Assemblies that do not satisfy the probe at station 16 are picked up and disposed into a container.

Station 19 – Clean Nest -- This station has a vacuum mounted to the tooling plate and when the tooling plate descends, the station head seals around the nest and an air blast throws the balls and dirt free while a vacuum removes the excess material.

Station 20 – Probe Empty Nest -- The probe at this station ensures that the nest is free of parts and assemblies before repeating the cycle at station 1.

MACHINE 12 – SENSOR CASE AND BOBBIN ASSEMBLY

Machine Description

Machine 12 is a 24-station, single-nested, dial-index machine (see Figure 25). This machine assembles the sensor case and bobbin assembly, which consists of the sensor release mechanism and case assembly from Machine 11, the ejection spring, the sensor bobbin assemblies from Machine 7, two locking balls, and a cap. The completed assembly is held in place by the formed tabs of the sleeve that protrude through slots in the cap and are formed over. The locking legs of the cap are then formed over to lock the sleeve tabs.

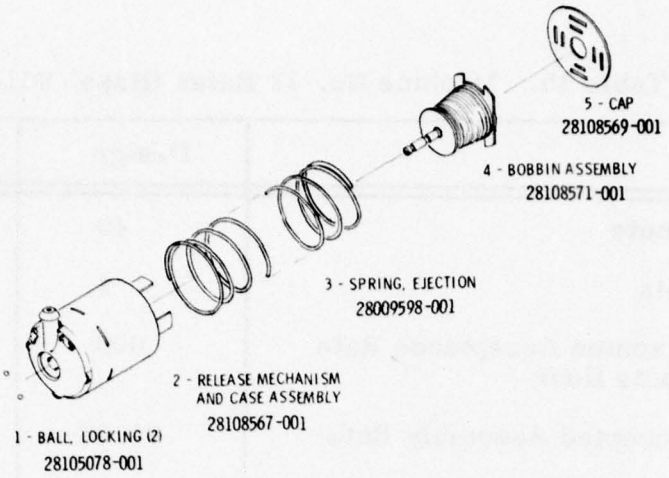
One of the operations on this machine is to predrill the bobbin (the final drilling for the bobbin separation is done on Machine 13).

One assembly is produced with each cycle of the machine.

The sensor release mechanism and case assemblies, ejection springs, and bobbin assemblies are supplied to the machine in magazines. The caps are vibratory bowl fed, and the locking balls are vacuum transferred from a container. See Table 15 for Machine No. 12 Rates.

Station Descriptions (See Figure 26)

Station 1 – Magazine Feed Sensor Release Mechanism and Case Assembly from Machine 11 -- Sensor release mechanism and case assembly from Machine 11 are delivered to this machine in magazines which are maintained in a stacker. As the magazines index, assemblies are made available for pickup and transfer at station 1.



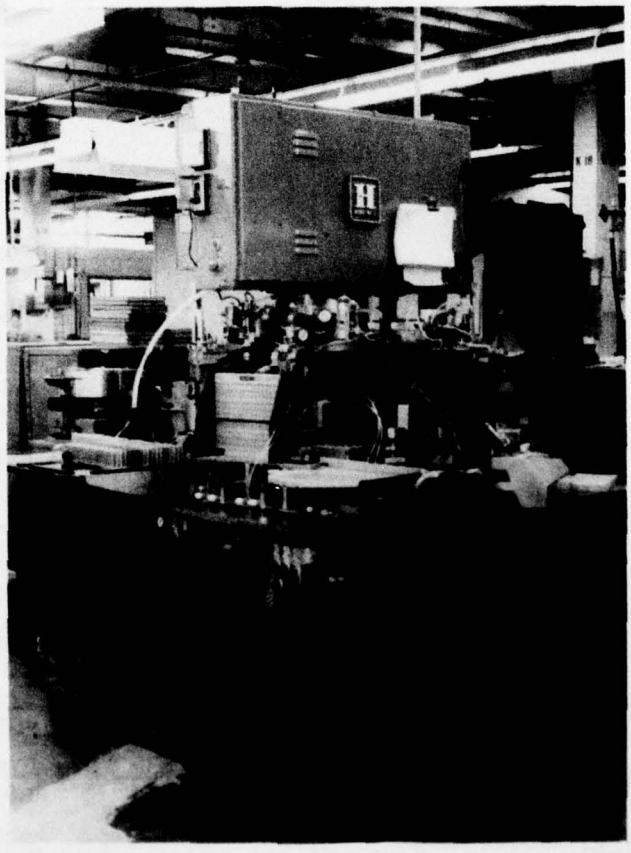


Figure 25. Machine No. 12 - Sensor Case and Bobbin Assembly

Table 15. Machine No. 12 Rates (Base OML 189)

	Design	Actual (11/77)
Cycles/Minute	40	26
No. of Tools	1	1
Average Machine Acceptance Rate per 60-Minute Hour	900	352
Machine Accepted Assembly Rate	60.0%	86%
Current Reject Rate		6.6%
Current Scrap Rate		4.8%

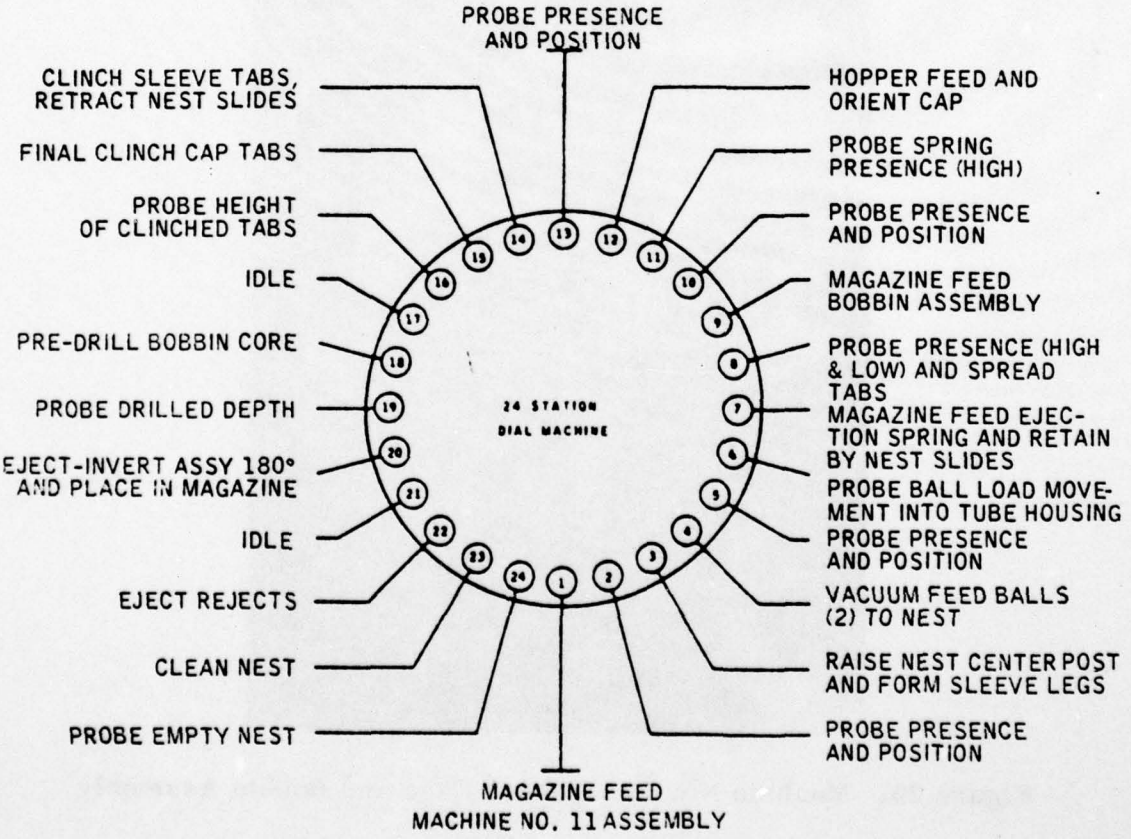


Figure 26. Machine No. 12 - Station Layout

Station 2 – Probe Presence and Position of Sensor Release Mechanism and Case Assembly -- An electromechanical probe mounted to the upper tooling plate probes the presence and position of the sensor release mechanism and case assembly.

Station 3 – Raise Nest Center Post and Form Sleeve Tabs -- The four sleeve tabs are formed slightly inward to ensure alignment with the cap. The nest center post is pushed up by a cam-operated rod located below the dial.

Station 4 – Vacuum Feed Two Locking Balls -- The demagnetized balls are picked up by means of a vacuum from a container and transferred into the assembly.

Station 5 – Probe Presence and Position of Locking Balls -- Two photo-interrupter sensors are mounted to the end of the probe attached to the upper tooling plate. The sensors detect whether the two balls are in proper position on each side of the chisel-shaped nest center post. Before the tooling plate goes up, a cam operated puller below the dial pulls the nest center post, allowing the balls to drop into the tube housing in the case assembly inside diameter. The nest center post is then raised to close off the balls.

Station 6 – Probe Locking Ball Movement into Tube/Housing Assembly -- An electromechanical probe mounted to the upper tooling plate probes for presence and position of the balls on either side of the nest centered post. If a ball is present, it did not drop into the tube housing at Station 5.

Station 7 – Magazine Feed Ejection Spring and Retain Spring with Nest Slide -- The ejection springs are supplied from Machine 12A in magazines and are blown into the assembly. The assembly is compressed and held in a compressed condition by nest slides that are moved in over the compressed spring.

Station 8 – Probe Presence of Ejection Spring and Spread Sleeve Tabs -- This station performs a dual task of probing for a properly compressed spring in the nest and also spreading the tabs of the sleeve to the proper dimension for accepting the bobbin and cap.

Station 9 – Magazine Feed Sensor Bobbin Assembly from Machine 7 -- The sensor bobbin assemblies are supplied in stick magazines and are in proper orientation for assembly. Sensor bobbin assemblies are picked up and transferred from the magazine into the assemblies.

Station 10 – Probe Presence and Position of Sensor Bobbin Assembly -- This station checks to ensure that the sensor bobbin assembly has been properly located in the assembly.

Station 11 -- Idle.

Station 12 – Vibratory Bowl Feed and Orient Cap -- The cap is oriented in a vibratory feed bowl and fed to a gravity track. The parts are isolated and are picked up and transferred into the assembly.

Station 13 – Probe Presence and Position of Cap -- This probe checks for the presence and position of the cap in the assembly.

Station 14 – Form Sleeve Tabs and Retract Nest Slide -- This station is mounted to the upper tooling plate and, as the plate lowers, a spring-loaded plate makes contact with the cap and exerts pressure to offset the pressure exerted by the ejection spring. While depressed, the nest slides are pulled free from the assembly and the tabs are formed.

Station 15 – Final Clinch Cap Tabs -- This station pre-bends the tabs on the cap over the sleeve tabs. As the tooling plate is lowered, the tooling at station 15 bottoms on the top of the nest and causes the four cap tabs to bend over the sleeve tabs.

Station 16 – Probe Height of Tabs -- This station checks to ensure that the finished height of the formed tabs is in accordance with the dimension specified.

Station 17 -- Idle.

Station 18 – Pre-Drill Bobbin Core -- If the probe at station 16 has been satisfied, the sensor indexes into this station and the bobbin core is drilled to the specified depth.

Station 19 – Probe Depth of Drilled Bobbins -- This probe checks the drilled hole depth to ensure that the bobbin is drilled as specified.

Station 20 – Eject, Invert Assemblies, and Place into Magazines -- All sensor case and bobbin assemblies that have been properly assembled will be ejected out of the nest, inverted 180 degrees, and placed into a magazine.

Station 21 -- Idle.

Station 22 – Eject Container -- This station picks rejected assemblies out of the nest and disposes them into a container.

Station 23 – Clean Nest -- This station vacuums the nest so that it is clean of assemblies, loose parts, and plastic tips.

Station 24 – Probe Empty Nest -- This probe determines if the nest is clear of rejected assemblies and other foreign material before starting the new cycle at station 1.

MACHINE 12A – EJECTION SPRING WINDER

Machine Description

The ADAM ejection spring winter (Figure 27) is an E. A. Samuel Machine Co. automatic spring coiler. This machine winds the ejection spring (28009598-001) that goes into the sensor case and bobbin assembly at Machine 12.

One spring is wound with each cycle of the winder.

The 0. 031-inch-diameter music wire is dereeled from a coil by a National Standard Co. slack wire feeder to the feed roll of the winder. The wire is coiled, cut to length, and air ejected to magazines. See Table 16 for Machine No. 12A Rates.

Station Descriptions

Station 1 – Dereel -- Large spools of wire (up to 700 pounds) are placed on the dereeler. The wire is threaded around smaller wheels and into the motor driven wheel. This unit maintains the proper amount of slack in the wire as it is fed into the winder.

Station 2 – Wind Spring -- Wire is pulled into the machine through wire guides by two sets of power-driven feed rolls. It is pushed around an arbor and controlled by the coiling point and pitch tool. The resulting spring is cut off and picked up in a receiver tube and blown clear of the machine by a venturii feed air blast into a plastic transfer tube.

Station 3 – Load Springs into Magazines -- The springs are blown through the tube into the magazines. Above the magazines is a Robatron sensor coil that detects if a magazine fails to advance causing the springs to stack. This ensures that there will be no empty cavities in the magazine.

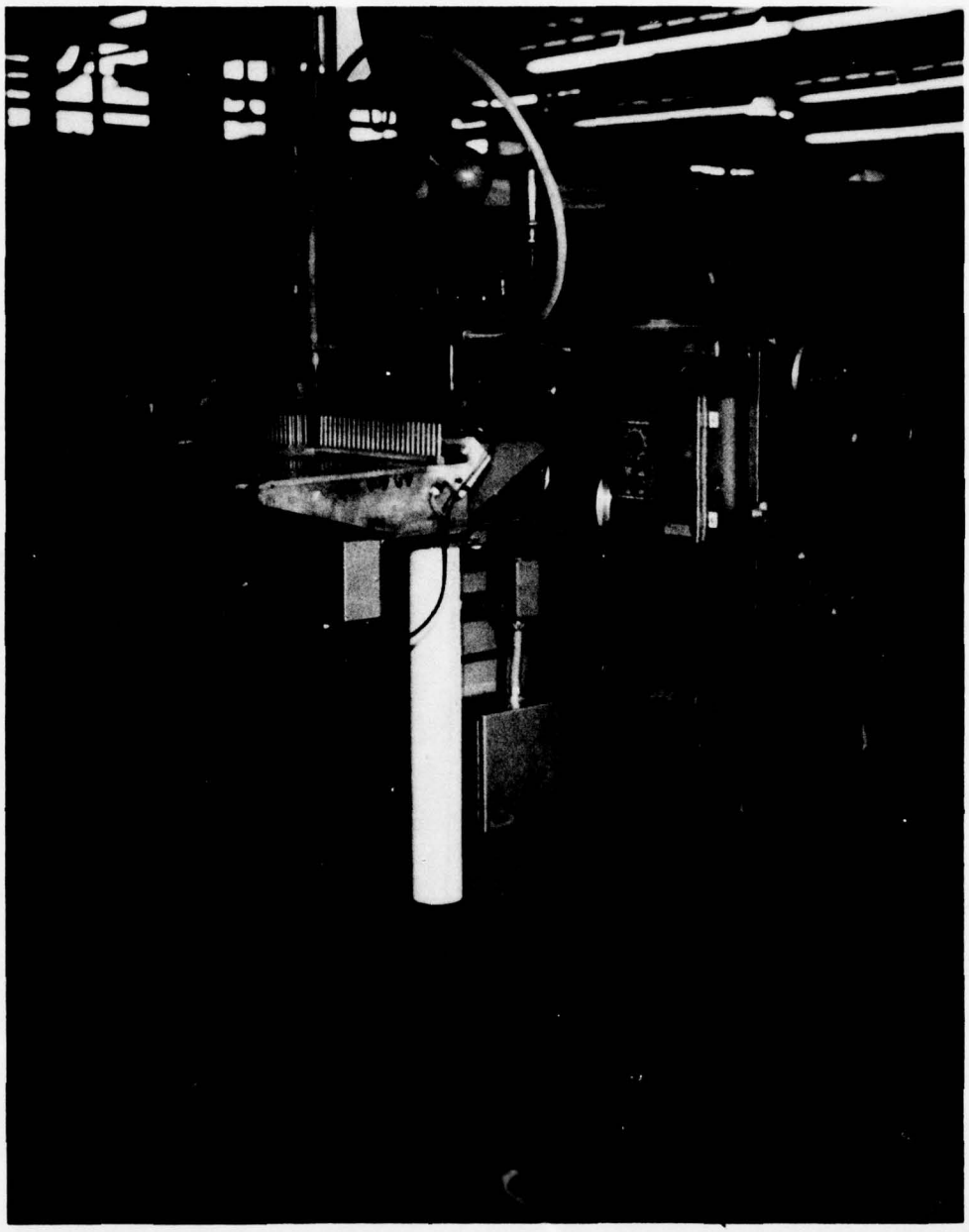


Figure 27. Machine No. 12A - Ejection Spring Winder

Table 16. Machine No. 12A Rates
(Base E. A. Samuel
Machine Company)

	Design	Actual (11/77)	
Cycles/Minute	---	---	Not Available
No. of Tools	---	---	
Average Machine Acceptance Rate per 60-Minute Hour	---	---	
Machine Accepted Assembly Rate	---%	---%	
Current Reject Rate		(1)%	
Current Scrap Rate		1.3%	
(1) No machine rejection			

MACHINE 13 – SENSOR AND BREAKWIRE ASSEMBLY

Machine Description

Machine 13 is a 24-station, single-nested, dial-index machine (see Figure 28). This machine assembles the sensor assembly, which consists of the sensor case and bobbin assembly from Machine 12, electrical magnet wire (breakwire), breakwire retaining ring, post cover, and tape. This machine also performs the final drilling operation on the bobbin to ensure breakaway when the sensor is deployed.

The breakwire is reflow soldered to both terminals, cut to length, and a continuity check performed. One assembly is produced with each cycle of the machine.

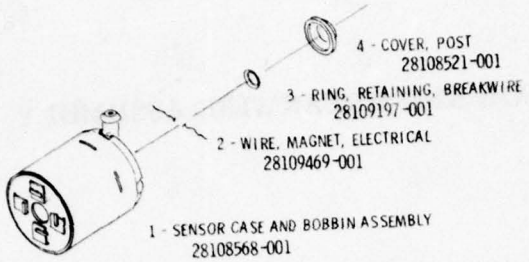
The sensor case and bobbin assemblies are magazine fed, as received from Machine 12, and the retaining rings and post covers are vibratory bowl fed. The wire is fed from a small spool. Completed assemblies are ejected into stick magazines and defective assemblies are rejected to containers. See Table 17 for Machine No. 13 Rates.

Station Descriptions (See Figure 29)

Station 1 – Magazine Feed Sensor Case and Bobbin Assembly from Machine 12 -- This station picks up and transfers the sensor case and bobbin assembly from the magazine into the nest.

Station 2 -- Idle.

Station 3 – Probe Presence and Position of Sensor Case and Bobbin Assembly -- This probe checks the presence and position of the sensor case and bobbin assembly in the nest.



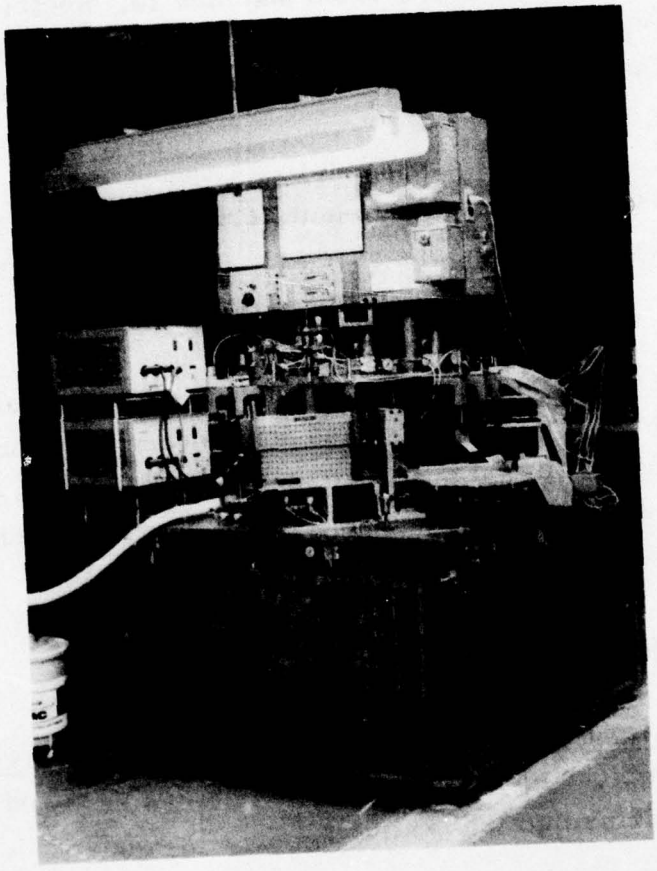


Figure 28. Machine No. 13 - Sensor Assembly

Table 17. Machine No. 13 Rates (Base OML 189)

	Design	Actual (11/77)
Cycles/Minute	40	26
No. of Tools	1	1
Average Machine Acceptance Rate per 60-Minute Hour	1250	387
Machine Accepted Assembly Rate	69.4%	82.8%
Current Reject Rate		8.2%
Current Scrap Rate		2.9%

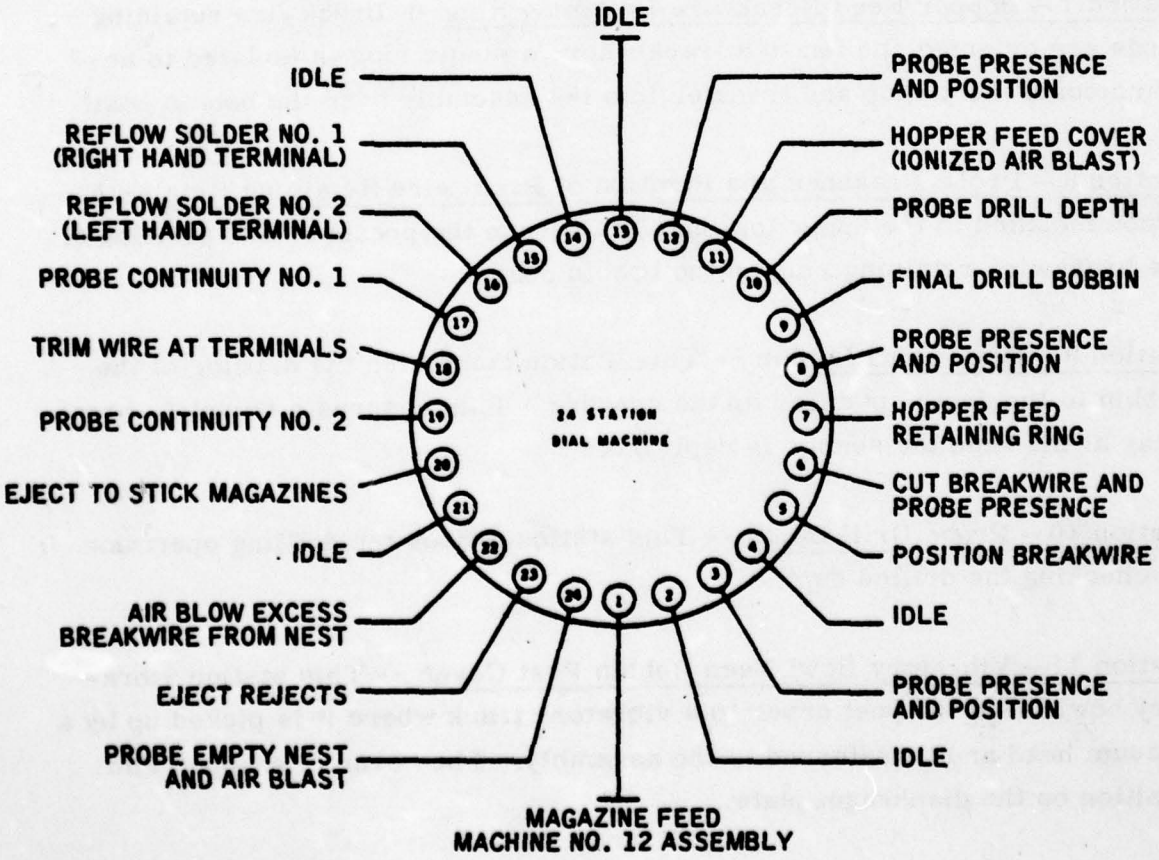
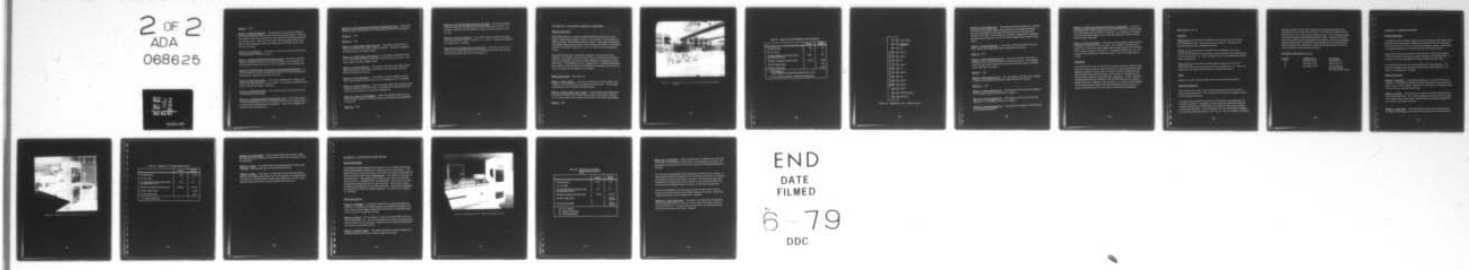


Figure 29. Machine No. 13 - Station Layout

AD-A068 625 HONEYWELL INC HOPKINS MN DEFENSE SYSTEMS DIV F/G 19/1
DEVELOPMENT OF A PROTOTYPE AUTOMATED ASSEMBLY MACHINE PRODUCTIO--ETC(U)
NOV 77 C B CHRISTENSEN DAAA21-73-C-0770
UNCLASSIFIED 47435 NL

2 OF 2
ADA
068625



END
DATE
FILMED
6 79
DDC

Station 4 -- Idle.

Station 5 – Position Breakwire -- The breakwire is positioned across the top of the assembly and held on both sides by spring-loaded pads. When the dial indexes, more wire is pulled from the spool and automatically positions over the next nest. At the end of the index, the tooling plate lowers and a probe on the tooling plate centers the bobbin post and inserts the wire into the slot of the post.

Station 6 – Cut Breakwire -- This station is mounted to the tooling plate and cuts the breakwire between the nests.

Station 7 – Hopper Feed Breakwire Retaining Ring -- Breakwire retaining rings are oriented and fed to a track where a single ring is isolated to accommodate the pickup and transfer into the assembly over the bobbin post.

Station 8 – Probe Presence and Position of Breakwire Retaining Ring -- A probe mounted to the upper tooling plate checks the presence and position of the breakwire retaining ring on the bobbin post.

Station 9 – Final Drill Bobbin -- This station completes the drilling of the bobbin to the depth specified on the drawing. This ensures a complete breakaway at the time the sensor is deployed.

Station 10 – Probe Drill Depth -- This station probes the drilling operation by checking the drilled depth.

Station 11 – Vibratory Bowl Feed Bobbin Post Cover -- This station vibratory bowl feeds the post cover to a vibratory track where it is picked up by a vacuum head and transferred to the assembly. The cover is snapped into position on the diaphragm plate.

Station 12 – Probe Presence and Position of Bobbin Post Cover -- This probe checks to ensure that the post cover is properly positioned on the assembly.

Station 13 -- Idle.

Station 14 -- Idle.

Station 15 – Reflow Solder Right Terminal -- This station reflows the tin coating on the terminal to make a solder connection. The power supply for this reflow solder is a Hughes welder.

Station 16 – Reflow Solder Left Terminal -- This station is identical to station 15 except that the solder connection is made to the left terminal. The power supply is another Hughes welder.

Station 17 – Probe Continuity -- This probe is mounted to the upper tooling plate and checks to ensure that the terminals were adequately soldered without arming the breakwires.

Station 18 – Trim Breakwire -- This station trims the breakwire on each side of the terminals so that loose wire is not dangling from the assembly.

Station 19 – Probe Continuity -- This probe again checks the continuity of the breakwire between the two terminals. It ensures that no damage was done at the time the breakwire was trimmed on station 18.

Station 20 – Eject to Stick Magazine -- After the assemblies pass the continuity check at station 19, they are picked up and deposited into magazines at station 20.

Station 21 -- Idle.

Station 22 – Air Blow Excess Breakwire from Nest -- As the dial indexes, a flat cam above the dial opens up the spring-loaded pins on the nest. An air blast, mounted on the tooling plate, blows the excess breakwire from the nest.

Station 23 – Eject to Container -- This station ejects assemblies that have been rejected by the probes at stations 10, 17, and 19. Rejected assemblies are deposited in a container.

Station 24 – Probe Empty Nest and Clean Nest -- This station probes each nest to make certain that all piece parts and assemblies have been ejected before the nest starts the next cycle at station 1.

MACHINE 21A – ELECTRONIC ASSEMBLY COMPONENT

Machine Description

The ADAM electronic assembly component inserter (Figure 30) is a 15-station, single-nested, pallet-transfer in-line machine. This machine is a USM Corporation DYNA/PERT assembly system. This machine assembles the printed wiring board assembly, which consists of a printed circuit board, resistors R1 and R2, capacitors C1, C2, C3, and C6, and the integrated circuit.

One printed wiring board assembly is produced with each cycle of the machine. The printed circuit boards are fed from the bottom of the stack, using a "coin changer" principle, and the resistors and capacitors are fed from reels. The integrated circuit is magazine fed. Completed assemblies are ejected to a tray and defective assemblies are rejected to a tray for rework. *See Table 18 for Machine No. 21A Rates.*

Station Descriptions (See Figure 31)

Station 1 – Meter Pallets -- This station holds the first empty pallet in the sequence. It is held in place by the pallet locating inserts. The returning empty pallets stack up behind the clamped pallet.

Station 2 – Feed Printed Circuit Board -- The automatic board loading station ejects a printed circuit board from the stack of boards and inserts it into a ramming plate which positions the printed circuit board onto a pallet.

Station 3 – Idle.

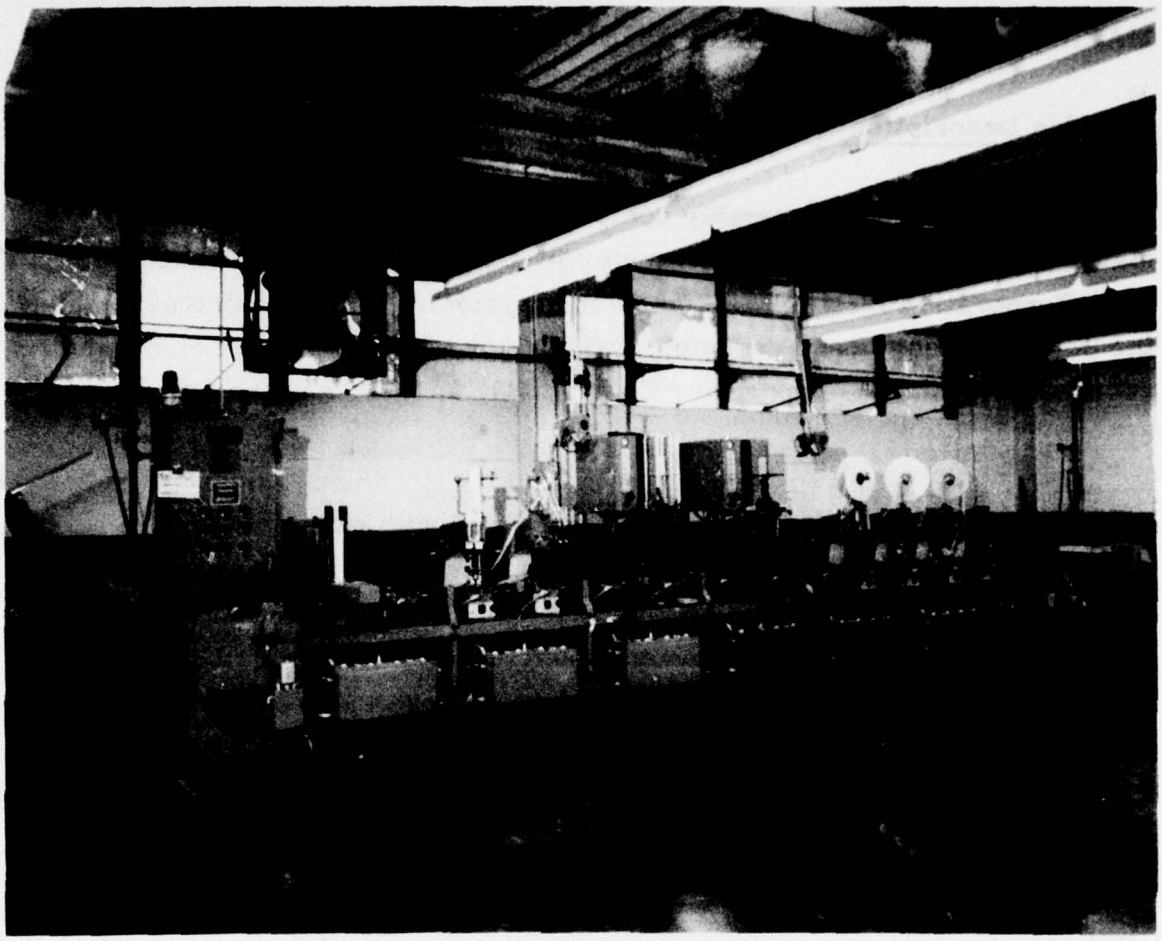


Figure 30. Machine No. 21A - Electronic Assembly Component Inserter

Table 18. Machine 21A Rates* (Base USM Corporation)

	Design	Actual (11/77)
Cycles/Minute	35	25
No. of Tools	1	1
Average Machine Acceptance Rate per 60-Minute Hour	1050	131
Machine Accepted Assembly Rate	70.0%	>99%
Current Reject Rate		(1)%
Current Scrap Rate		0.5%

*21A Replaced
Lower Electronics Assembly Machines 21, 22, 23

(1) No machine rejection, 100% visual inspection

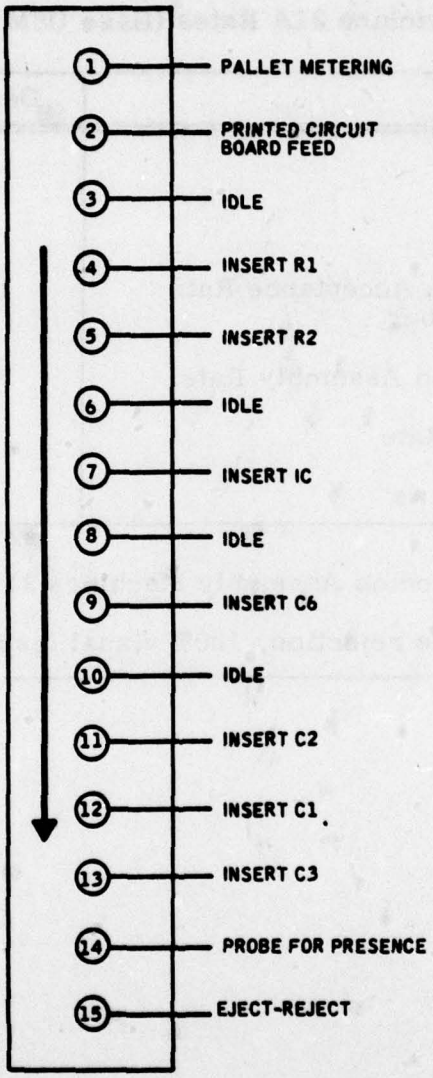


Figure 31. Machine No. 21A - Station Layout

Station 4 – Insert Resistor R1 -- This station reel feeds resistor R1, cuts the wire leads to the proper length, forms the leads into a staple-like shape, and inserts the leads into the holes which have been pre-punched to the printed circuit board. As the leads are inserted, a wiping anvil mechanism operates below the board to clinch the lead ends against the underside of the board.

Station 5 – Insert Resistor R2 -- This station reel feed resistor R2 and inserts, forms, and crimps the leads as described for station 4.

Station 6 -- Idle.

Station 7 – Insert Integrated Circuit -- This DIP component is fed from a magazine into the feed station where the leads are formed. The integrated circuit is inserted into the printed circuit board and the leads are crimped on the underside of the board.

Station 8 -- Idle.

Station 9 – Insert Capacitor C6 -- The reel feeding, insertion, and crimping of leads at this station are identical to that described for station 4.

Station 10 -- Idle.

Station 11 – Insert Capacitor C2 -- This station inserts and forms capacitor C2 in the same manner as described for station 4.

Station 12 – Insert Capacitor C1 -- This station, which inserts and forms capacitor C1, is identical in function to station 4.

Station 13 – Insert Capacitor C3 -- The insertion of capacitor C3 is the same as described for station 4.

Station 14 – Probe for Presence and Position of Components -- An electro-mechanical head contains probes that contact the printed circuit board in the areas that should contain inserted components. If a component is missing, an electrical memory signal is sent to the next station to reject the board when it reaches that point.

Station 15 – Eject and Reject -- The board unloading station unloads printed wiring board assemblies from the pallet. The completed assemblies are ejected into a chute which has a flipper that is either right or left depending on the memory signal from station 14. Acceptable assemblies go to a tray on the left side and defective assemblies go to a tray on the right side for rework.

Background

The original plan for this machine did not include insertion of the thick film resistor (conformal coated), three transistors or the antidisturbance switch. Sufficient modules were purchased to make the addition of these insertion heads possible if and when the printed circuit board is redesigned to provide the space required to insert the three transistors, or if the conformal coating requirement was eliminated from the thick film and/or a special insertion head was designed to accommodate it. A module is also available for the antidisturbance switch if the switch design is revised to permit a crimp of the leads to hold it to the board during subsequent handling.

MACHINES 21, 22, 23

Functions

Machine No. 21 was planned to assemble the printed circuit board, thick film, integrated circuit, two capacitors and a resistor. Each was to be automatically inserted, clinched and probed.

Machine No. 22 was planned to assemble three transistors and one resistor to the assembly three transistors and one resistor to the assembly produced on Machine No. 21. Each component was to be automatically inserted, clinched and probed.

Machine No. 23 was planned to assemble three capacitors and the anti-disturbance switch to the assembly produced by Machine No. 22. Each component was to be automatically inserted, clinched and probed.

Bases

Standard 24 station OML 189 Bases were used for the three machines.

Machine Development

The machines were built, put into the debug phase and several revisions made to working stations. The revisions did not provide a workable concept for insertion and crimping.

An estimate was prepared for the cost of developing a new concept and revising the machines. Investigation of other electronic component insertion machine manufacturers revealed that two companies had machines capable of inserting components. Their estimated costs were less than the estimate to revise the existing machines 21, 22, and 23. The one company, Universal,

required a printed circuit board layout with all components aligned to accommodate their x-y approach to insertion. This was not possible with the ADAM printed circuit board layout requirements for survival during function. The second company, United Shoe Machinery (USM), stated that they could insert seven of the twelve components but the clearance between components would not enable them to insert the three transistors and special insertion heads would need to be developed to insert the antidisturbance (AD) switch and the conformal coated thick film resistor.

Disposition of Machines 21, 22, 23

Machine	Original Source	Reworked to
21	WAAPM G31519	ADAM SAAF 25
22	WAAPM G31504	ADAM SAAF 19
23	WAAPM G31520	Lithium Battery (St. Louis Park) Cathode Machine G2666

MACHINE 24 – RESISTER TRIMMER

Machine Description

The ADAM resister trimmer (Figure 32) is a one-station, dual-nested, laser trimmer built by Korad and controlled by a Honeywell H316 minicomputer. This machine trims LVD, F1, and F2 on the resister network. One printed circuit board assembly is trimmed with each cycle of the machine.

One printed wiring board assembly is located onto a nest by the operator while the trimmer is working on another assembly in an adjacent nest. At the end of the cycle, the operator unloads and loads the other nest.

The terminal printer provides status printouts for each assembly. The operator segregates rejected units by defect for salvage operations. See Table 19 for Machine No. 24 Rates.

Station Descriptions

Station 1 – Controller -- The system controller is a Honeywell H316 minicomputer. It monitors the system functions, the assembly parameters and output system control signals, diagnostics to the printer, and accepts inputs from the operator through the terminal.

Station 2 – Printer -- The terminal is a Texas Instruments Silent 700 with a dual-cassette tape deck. The control program is stored on a cassette tape and is loaded from this terminal. System status and assembly diagnostics are printed for permanent records.

Station 3 – Laser Head -- The laser head does the actual trimming of the resisters by destroying resist material on the thick-film resister network.

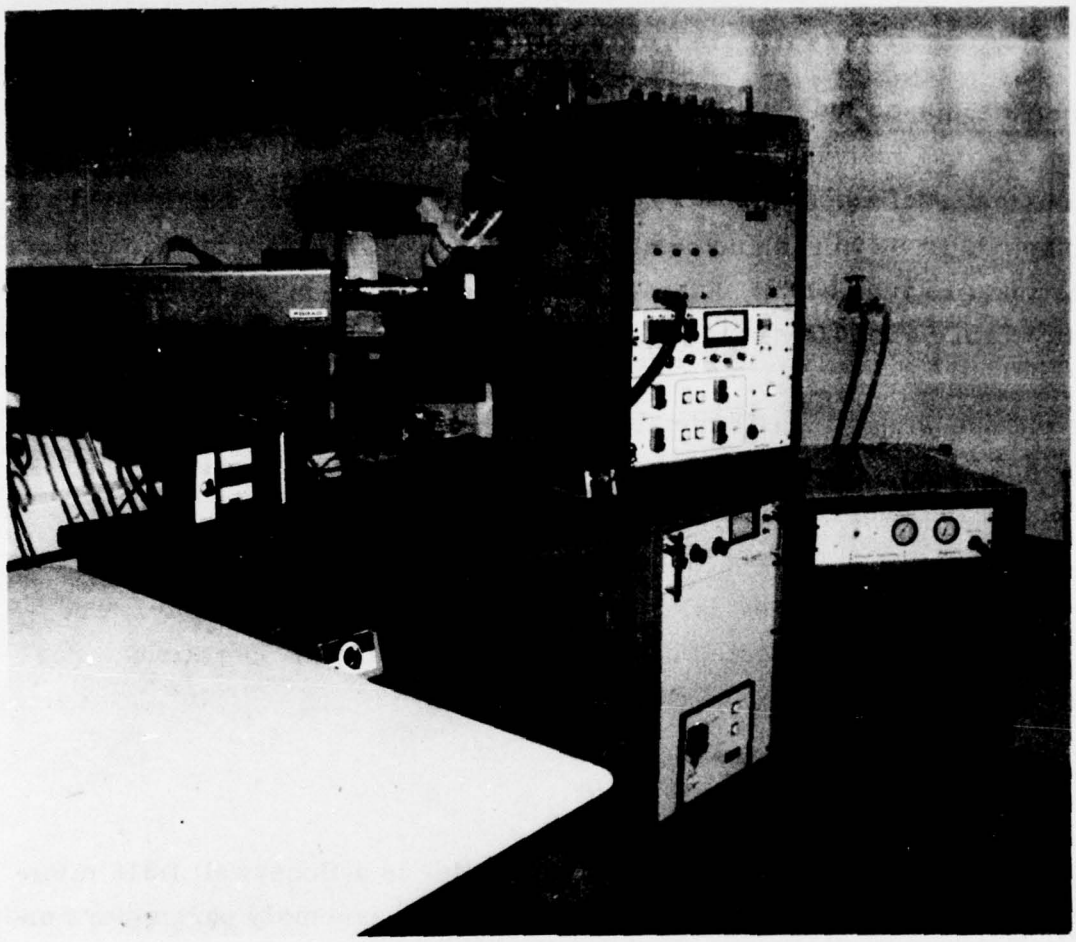


Figure 32. Machine No. 24 - Resistor Trimmer

Table 19. Machine No. 24 Rates (Base Korad)

	Design	Actual (11/77)
Cycles/Minute	N/A	2.43
No. of Tools	1	1
Average Machine Acceptance Rate per 60-Minute Hour	128	48
Machine Accepted Assembly Rate	90-95%	95.9%
Current Reject Rate		4.2%
Current Scrap Rate		(1)%

(1) 100% salvageable

Station 4 – X-Y Axis Table -- The X-Y axis table moves the laser optics. The computer gives direction to the table for start point, direction of trim, and stop point.

Station 5 – Cooler -- The laser head is cooled by the water-to-water heat exchanger. Recirculating water is de-ionized and filtered.

Station 6 – Viewer -- The viewer is a television screen that provides the operator with a high magnification view of the resister area being trimmed. The operator can make manual starting point adjustments to the X-Y axis table and verify them before, during, and after the trim cycle.

MACHINE 26 – ELECTRONIC SYSTEM TESTER

Machine Description

The ADAM electronic system tester (Figure 33) is a 16-station test system built by Honeywell and controlled by a Honeywell H316 minicomputer. This tester runs up to 13 groups of tests on the printed wiring board assembly and the final functional test on the wedge assembly. The system is split into two six-nest testers. Six assemblies are located on the nests by the operator while the tester is testing the other six assemblies. At the end of the cycle, the operator unloads and loads the other six nests. The terminal printer provides status printouts for each tested assembly. The operator segregates rejected units by defect for salvage operations. See Table 20 for Machine No. 26 Rates.

Station Descriptions

Station 1 – Controller -- The system controller is a Honeywell H316 minicomputer. It monitors the system functions, the assembly parameters and output system control signal, diagnostics to the printer, and accepts inputs from the operator through the terminal.

Station 2 – Printer -- The terminal is a Texas Instruments Silent 700 with a dual-cassette tape deck. The control programs are stored on cassette tapes and are loaded from this terminal. Systems status and assembly diagnostics are printed for permanent records.

Station 3 – Interface Panel -- This panel provides the interface between the assemblies under test and the controller inputs and outputs.

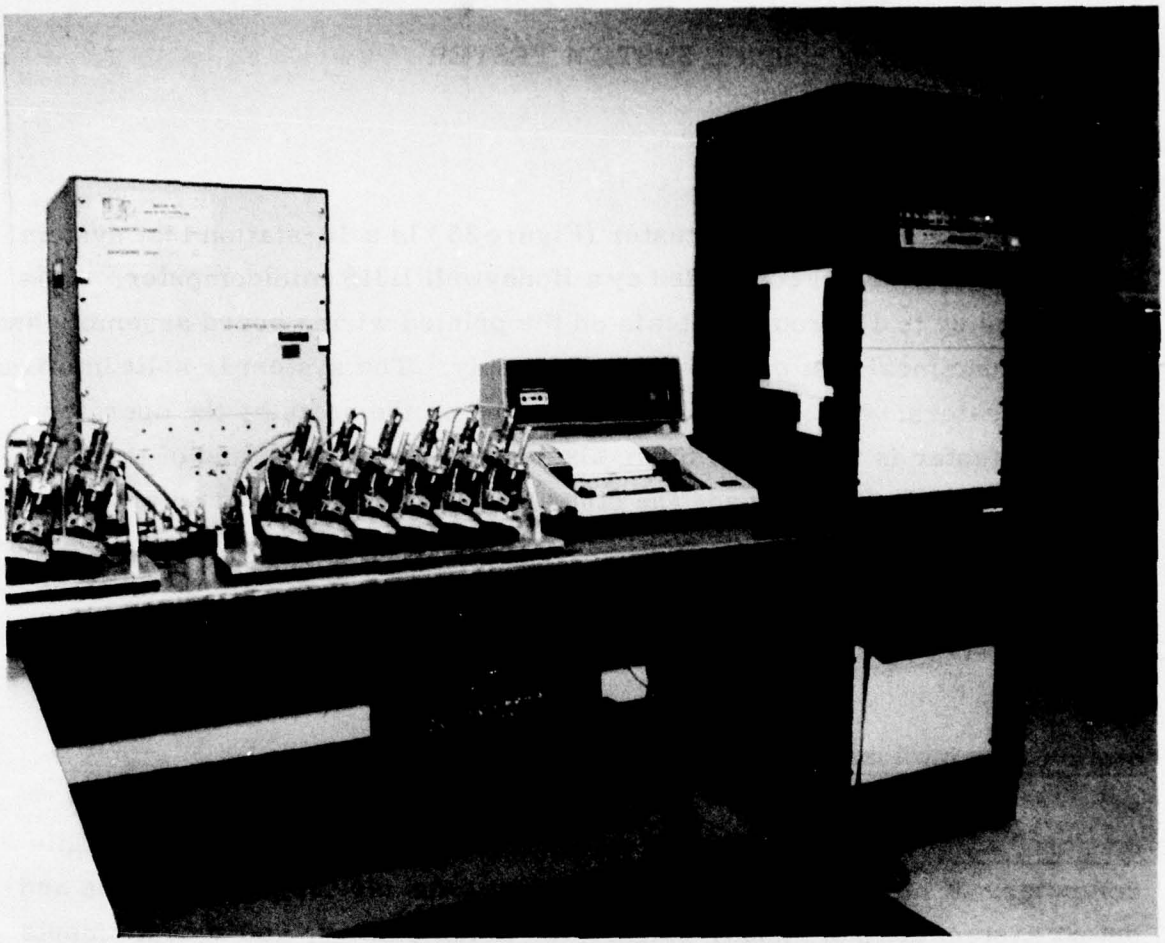


Figure 33. Machine No. 26 - Electronic System Tester

Table 20. Machine No. 26 Rates (Base Honeywell M&TE Lab)

	Design	Actual (11/77)
Cycles/Minute	N/A	6.3
No. of Tools	1	1
Average Machine Acceptance Rate per 60-Minute Hour	128	53
Machine Accepted Assembly Rate	N/A%	88.9%
Current Reject Rate		15% (1) 5% (2)
Current Scrap Rate		(3) (1) 5% (2)

(1) P.C. Boards
(2) Wedge Assemblies
(3) 100% Salvageable

Station 4-15 – Test Nests -- Twelve identical nests, separated into two banks of six each, are mounted to a work table for the assemblies under test. Six assemblies in one bank are tested while the operator exchanges assemblies in the other.

Each nest has spring-loaded pins to electrically contact the circuit paths. A cable provides electrical connection to the interface panel and an air cylinder is provided to clamp the assemblies into place. When printed wiring board assemblies are being tested, the air cylinder clamp rods are locked in the top detent and the adapter plates are placed over the spring-loaded pins.

When final assemblies are being tested, the air cylinder clamp rods are locked in the bottom detent and the adapter plates are removed. Probes are mechanically picked up and dropped into a container.

Station 16 – Probe Empty Nest -- The probe is lowered by the tooling plate, and microswitches open or close the circuit to show if the nest is empty or if a part is still in it. If a part remains in the nest, the machine will stop before the nest reaches the station 1 position.